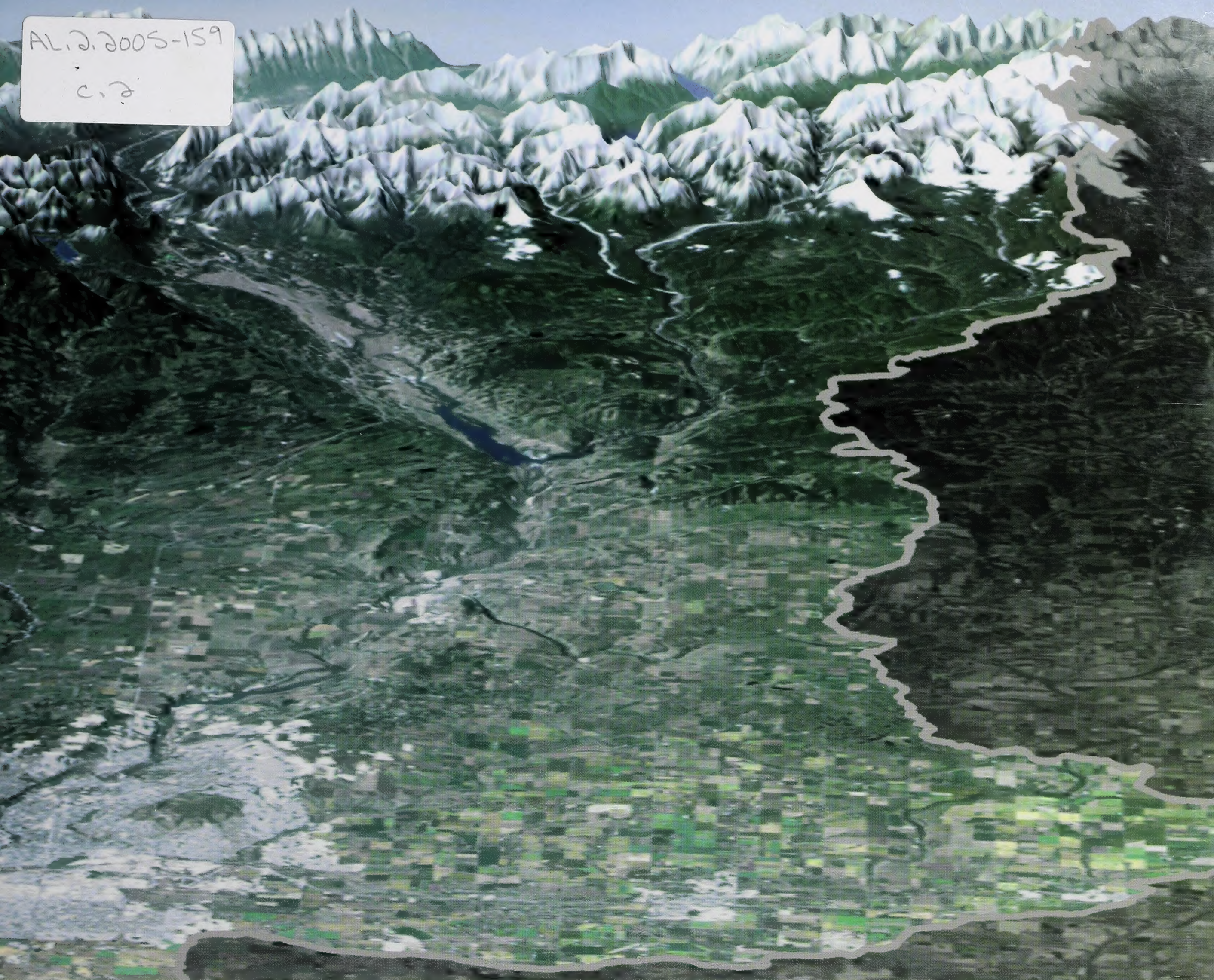


Bow River BASIN Council

NURTURE • RENEW • PROTECT

The 2005 Report on the State of the Bow River Basin

The Bow River Basin Council (BRBC) is a multi-stakeholder, charitable organization dedicated to the improvement and protection of the Bow River Basin. This includes activities that focus on the quality and quantity of water in the Bow River and its tributaries, their riparian zones, aquatic ecosystems and the effects of land use in the basin on the surface and groundwater resources.

To this end, the BRBC will:

1. Hold quarterly educational forums to provide opportunities to discuss and learn more about current issues and events occurring in the basin and maintain a base for the sharing of perspectives and the exchange of information.
2. Prioritize water use management issues that may affect the quality and/or quantity of groundwater, surface water and riparian zones in the basin.
3. Develop improved water use management procedures, performance measures and recommendations about the future of water management in the South Saskatchewan River Basin.
4. Partner with and provide funding to individuals, groups, corporations, academics and environmental organizations to provide the highest possible protection for the Bow River Basin.
5. Publish a regular State of the Basin Report that will provide up-to-date information on the basin's water quantity, water quality and ecosystems, and act as a baseline from which to compare future trends and changes.

The purpose of this report is to provide information to:

- Improve the overall understanding of the Bow River Basin through the analysis of data, current information and trends (i.e., education).
- Facilitate decision-making for water issues in the Bow River Basin.
- Engage the general public, stakeholders and resource managers in discussion, and through these discussions, make meaningful recommendations for future improvements.

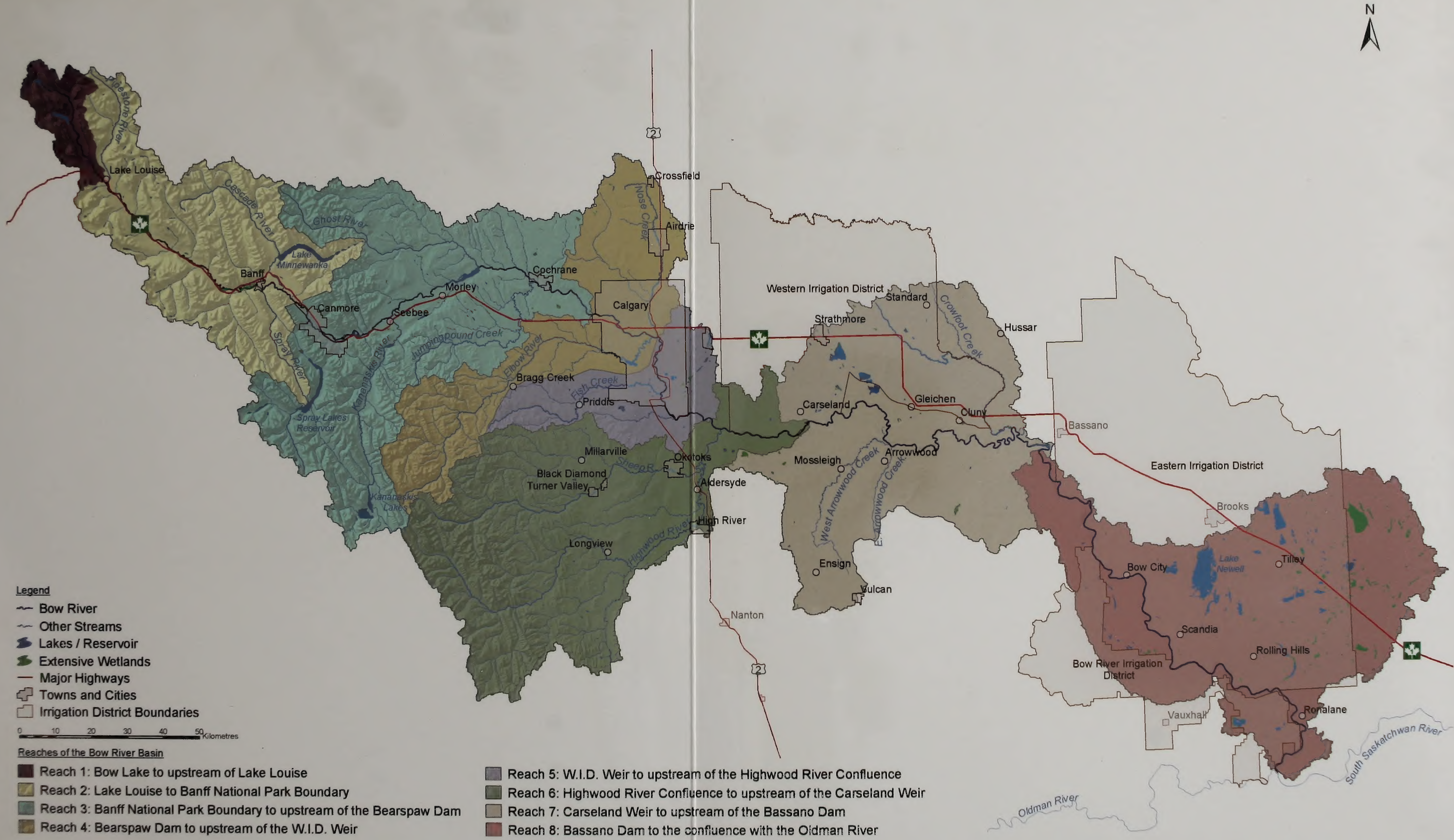
COUNCIL'S VISION FOR THE WATERSHED

The Bow River Basin is conserved and protected as a fragile and unique resource and recognized as our lifeline. Multiple uses are balanced, ensuring the needs of all stakeholders are met, while maintaining a healthy ecosystem.

Nurture · Renew · Protect

A Report on the
State of the Bow River Basin

Bow River
BASIN
Council


N
Lake Louise
Pipestone River
Cascade River
Ghost River
Lake Minnewanka
Banff
Canmore
Spray River
Spray Lakes Reservoir
Kananaskis River
Kananaskis Lakes
Morley
Seebee
Jumpingpound Creek
Cochrane
Crossfield
Nose Creek
Airdrie
Calgary
Elbow River
Bragg Creek
Fish Creek
Priddis
Millarville
Sheep R.
Black Diamond
Turner Valley
Okotoks
Aldersyde
High River
Highwood River
Longview
Nanton
Western Irrigation District
Standard
Strathmore
Crowfoot Creek
Hussar
Carseland
Gleichen
Cluny
Mossleigh
Arrowwood
West Arrowwood Creek
East Arrowwood Creek
Ensign
Vulcan
Bassano
Eastern Irrigation District
Brooks
Bow City
Lake Newell
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Scandia
Rolling Hills
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Ronalane
South Saskatchewan River
Oldman River
Legend
Bow River
Other Streams
Lakes / Reservoir
Extensive Wetlands
Major Highways
Towns and Cities
Irrigation District Boundaries
0 10 20 30 40 50 Kilometres
Reaches of the Bow River Basin
Reach 1: Bow Lake to upstream of Lake Louise
Reach 2: Lake Louise to Banff National Park Boundary
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Reach 5: W.I.D. Weir to upstream of the Highwood River Confluence
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Nurture · Renew · Protect

A Report on the State of the Bow River Basin

Bow River Basin Council

Nurture, Renew, Protect:
A Report on the State of the Bow River Basin

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Alberta's 100th anniversary brings much prosperity now and promise for the future, but that promise is based in large part on our natural resources, particularly one resource we can't live without – water. More than 1 million people now live, work and play within the Bow River Basin and depend on the river and its tributaries. We draw our livelihood from the river and the thin ribbons of water flowing from the glaciers, wetlands and springs that are sprinkled along the eastern slopes of the Rocky Mountains. Many of us have our favourite memories of the Bow River Basin: hiking the glaciers, whitewater canoeing near Lake Louise, family picnics at Bow Falls, fly-fishing on a quiet reach, or a simple float through our town in an inner tube on a hot summer day.

In many ways, the easy part is behind us. Our development of the natural resources and land in the basin, while respectful of the need to balance economic prosperity with environmental protection, will increasingly place demands on this limited and precious water resource. Climatic factors which stress our water supply will not be quickly changed. Those factors that are under our control will force us to seek out hard-to-find compromises and perhaps make some difficult choices.

In this, our second State of the Basin Report, we invite you to join us on a journey down the reaches of the Bow River. Together, we will celebrate small gains, encounter new issues, and contemplate the challenges facing our watershed. We will learn more about our impacts on the sustainability of this valuable lifeline and perhaps gain a glimpse of where we can begin to focus our efforts. We have much important work to do and encourage you to join us.

Thank you for your interest, and welcome to the Bow River Basin.

Bill Berzins
Chairman
Bow River Basin Council

As co-chairmen of the report steering committee, we are pleased to present the 2005 State of the Bow River Basin Report "Nurture, Renew, Protect." This report updates the 1994 State of the River report and has an expanded focus on the watershed. This time, we evaluated trends in water quality, water quantity, natural ecosystems and stewardship.

The Bow River is a lifeline for more than a million people. It provides water for drinking and industry, electrical power and recreational opportunities. It's also a resource that renews our spirit and provides immeasurable aesthetic value to our lives. But the basin is not without its challenges. Forecasted growth and increased pressure on this natural resource urges us to act now and meet these challenges. The success of the Bow River Basin Council will, in large part, be determined by the active involvement of you, the reader. Reading and understanding this document is the first step in becoming familiar with the challenges of managing the Bow River Basin. We hope the report helps you gain an appreciation for the complexity of the issues and the variety of the river basin's users.

Residents of the basin, and indeed, all Albertans, should recognize and celebrate the contributions the Bow River watershed makes to our personal and professional lives. The Bow River is truly a map of our past and the health of its basin will help chart our future. We expect this report will provide its readers with the information upon which to make educated and responsible decisions, with the goal of maintaining the Bow River and its basin as a healthy resource for future generations to use and enjoy.

Gary Kindrat

Jay White

Co-chairs

State of the Bow River Basin
Report Steering Committee

Board of Directors

BOW RIVER BASIN COUNCIL

Bill Berzins (Commercial/Industrial) chairman of the Bow River Basin Council for the last five years, has a long history of involvement with environmental protection and enhancement in Alberta. He is a professional engineer and a founding partner of Fossil Water Corporation, an Alberta-based firm dedicated to providing water and wastewater solutions to the energy sector. Bill has almost 25 years experience in engineering and operations management, with an emphasis on designing, building, operating and financing projects. He also works closely with Earth Tech Canada in public-private partnerships for water, wastewater and composting operations throughout western North America.

Barry Erskine (Municipal Government) is First Vice Chair of the Bow River Basin Council. He was elected to his fourth term as Alderman for Calgary's Ward Eleven in October 2001. He is an environmentalist and respected horticulturalist. Barry holds a B.Sc., as well as a Journeyman Gardeners Certificate and a Certificate of Adult and Continuing Education from the U of C.

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Jay White (Commercial/Industrial) is a Co-Chair of the State of the Basin Report Steering Committee. He holds an M.Sc. in Ecology from the University of Alberta, with a specialization in water quality and is active with the Alberta Society of Professional Biologists and the Alberta Lake Management Society, as well as the BRBC. He manages Aquality Environmental Consulting Ltd. in Edmonton and is currently Project Manager for the North Saskatchewan Watershed State of the Basin Report.

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Robert Crow Chief (Regulatory, Administrative, First Nations) is a member of the Siksika First Nation.

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Steve Meadows (Individual Public Member) is a petroleum engineer working as Chief Engineer for a private firm in Calgary. He has a B.Sc. in Electrical Engineering from the University of Calgary and has a particular interest in issues relating to water quality and quantity. Steve divides the bulk of his volunteer efforts between the BRBC and the Calgary River Valleys Committee of the Calgary Parks Foundation. He has chaired the Bow River Basin Advisory Committee since January 2002.

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Rob Wolfe has been working with Alberta Environment for the last decade. He has been actively involved with the various phases of the South Saskatchewan River Basin Water Management Plan, Alberta's Water for Life Strategy, and the City of Calgary Parks Foundation Wetland Committee. He has undergraduate degrees in Biology and Geology and a Master's of Environmental Design from the University of Calgary.

Mark Bennett has been the Executive Director of the Bow River Basin Council for the past 5 years. He has previously worked in environmental monitoring and reporting and in emergency management, dealing with forest fires and floods. He was the Emergency Program Coordinator for the City of Winnipeg during the historic flood of 1997. Mark received B.Sc. in Biology from Queen's University and has both a Certificate in Public Sector Management and a Masters in Public Administration from the University of Manitoba. He is currently pursuing an Environmental Management Certificate from the University of Calgary and a Non-Profit Management Certificate from Mount Royal College.

Mike Murray has been the Administrator for the Bow River Basin Council for the last two years. He is a graduate of the University of Calgary with a B.Sc. in Ecology. Before joining the Council, Mike worked in industry and environmental research.

Missing from the photo: Judy Stewart, Robert Crow Chief, Lis Dixon

Acknowledgements

Nurture, Renew, Protect: A Report on the State of the Bow River Basin is the culmination of a tremendous amount of work and effort on the part of many people. The Bow River Basin Council desires to recognize and thank all contributors.We sincerely believe no contribution, either individually or organizationally, was too small or insignificant as to be unworthy of credit, and apologize if we have missed anyone.

Many BRBC members contributed to the credibility of this report, but special mention must be made of those who served on the project Steering Committee. The Steering Committee was originally chaired by David Hill and subsequently co-chaired by Gary Kindrat and Jay White. Also on the Committee were Norm Carlson, Yin Deong, Jane Toews, Heinz Unger, Jim Webber and Rob Wolfe. A very special citation goes to Jim Rouse, who freely shared his considerable wisdom and helped mentor the Committee. Jim also served as a content reviewer.

Other BRBC members contributed through their submissions to the content of the report. Every effort has been made to acknowledge this important contribution in the text, but it certainly bears mentioning again here. This report benefitted greatly from careful review by a number of expert external reviewers. The BRBC's heartfelt thanks is extended to Sherri-Dawn Annett, Rod Bennett, Kent Berg, Wally Chinn, Don Cockerton, Roger Drury, Paul Fesko, Anil Gupta, Ed Hofman, Jon Jorgenson, Brian Lajeunesse, Dave Nielsen, Doug Ohrn, Brent Paterson, Randy Poon, Trevor Rhodes, Al Sosiak, Jim Stelfox, Tom Tang and Pat Young.

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In any good report, layout is important. The BRBC offers sincere thanks to Bonnie Hofer for her creative contribution toward the report's visual appeal. The Bow River Basin Council also wishes to acknowledge the contributions of the Irrigation Branch of Alberta Agriculture, Food and Rural Development in the production of this report. Their cooperation in providing access to photo, text and graphics production facilities is very much appreciated.

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58. Urban Systems
59. Chris Vermeeren
60. A Warren Wilson
61. Wonder of Water

[1] Alberta Environment contributed through the provision of a Matching Grant.

Table of Contents

Executive Summary

The Bow River Basin is home to more than one million Albertans and welcomes hundreds of thousands of visitors every year. Valued for its beauty, and as a home for diverse fish, wildlife and plant communities, it is under immense pressure from a growing urban community and various land use impacts. This report, written for the Bow River Basin Council (BRBC) and its stakeholders, addresses the challenges faced by those whose task it is to ensure the responsible use and conservation of water resources in the basin. It updates and expands on the 1994 BRBC State of the River report.

Most of the Bow River Basin is highly altered from its natural state. Hydroelectric generation, effluent dilution, and water allocation for irrigation, municipal, industrial, agricultural, and recreational uses impact the natural flows of the river. By the time the river reaches its confluence with the Oldman River, 68% of its average annual flow has been allocated, although actual consumption is currently lower. Of the allocated water, 76% is licensed for irrigation. Population growth has placed additional demands on the water supply in the last decade and will likely become a greater challenge in the future. Climate change and glacial retreat add uncertainty to the quantity of flows for the future. Any new allocations will have a significant risk of not receiving water in drier years.

Human activities within the basin also influence water quality and the ecosystem. The impacts of stormwater runoff and wastewater effluent are particular challenges. Water quality declines along the length of the Bow River, with higher concentrations of nutrients and pesticides in the lower reaches. Fish and riparian habitat are negatively impacted by the fluctuations in stream flows and reservoir water levels caused by hydroelectric facilities. Several dams and weirs are barriers to fish movement. Lower spring and summer flows have also resulted in poor regeneration of cottonwood trees, which may disappear from the lower reaches in the next 100 to 150 years. Habitat degradation, heavy angling pressure and introduced fish species have reduced the distribution and number of some native fish species. Invasive plants are established and wetlands have been destroyed to allow for development or agricultural production.

But the picture is not all negative; many positive activities are ongoing within the basin. The BRBC and other organizations, government agencies and individual citizens have been addressing these issues for the past 13 years with a fair degree of success. Recent actions have led to great improvements in wastewater treatment by the City of Calgary and several smaller communities, the restoration of wetlands by organizations such as Ducks Unlimited and the Eastern Irrigation District, and water conservation programs by many municipalities and the Irrigation Districts. Many new stewardship groups and initiatives have been formed as a result of greater awareness of the issues, including Water for Life: Alberta's Strategy for Sustainability. Volunteer groups and individuals have initiated assessment, renewal and protection programs.

Recommendations for the future focus on six themes:

1. Development of the Bow River Integrated Watershed Management Plan
2. Appropriate use and sharing of technology
3. Preparation of a Water Balance Sheet
4. Continued research and monitoring
5. Public consultation and engagement
6. Pro-active contingency planning

Through implementation of these recommendations, current management practices may be improved to mitigate or avoid further pressure on the basin's resources. We now recognize and have an understanding of the many challenges facing the Bow River Basin. It is now time for all of us to take action and address them.

Bow River at Calgary

Chapter 1

Bow Glacier – R.Blanchard

Chapter 1

The Bow River Basin

1.1 Purpose of the Report

The Bow River Basin is the most highly populated river basin in Alberta. For the more than 1.12 million people living within this watershed, the flows of the Bow River sustain many aspects of their lives. The Bow River provides drinking water and other domestic requirements, agricultural and industrial opportunities, electricity, and recreational enjoyment. From its headwaters to its mouth, the Bow River also sustains many different natural ecosystems, essential for their intrinsic significance as well as their economic and aesthetic values.

Increasing human demands on the Bow River Basin inevitably conflict with environmental requirements. Finding and maintaining a successful and sustainable balance is the goal of various stakeholders within the basin. No one jurisdictional body is solely responsible for the management of the natural resources of the Bow River Basin; rather, it is shared by various municipal, provincial and federal governments, First Nations groups, industries, irrigation districts, and grassroots organizations. Ultimately, every person living in the basin bears some responsibility for its present and future state.

The Bow River Basin Council (BRBC) also plays a role in the effective management of the Bow River. The BRBC was established in 1992 in response to recommendations from the Bow River Water Quality Task Force. The Honourable Ralph Klein, then Alberta's Minister of Environment, created the Task Force to respond to long-standing concerns of several agencies and water users regarding deteriorating water quality in the Bow River.

The BRBC committed to produce a report containing reliable, high-quality information that could be used to make informed decisions regarding water management in the basin. It was also intended to help educate and inform the public about the basin's characteristics, environment, pressures, and management options. In 2004, the Government of Alberta formally recognized the BRBC as the Watershed Planning and Advisory Council for the Bow River Basin.

The first report was published in 1994 and was entitled "Preserving Our Lifeline: A Report on the State of the Bow River."[57] An important change in the focus of this, the present report, is reflected in its title. "Nurture, Renew, Protect: A Report on the State of the Bow River Basin" covers a broader mandate. As in the first report, the state of the entire Bow River is assessed, but this report has been extended to also include vegetation, wildlife and human use of the land, linking the river to its watershed. The river is assessed on a reach-by-reach basis, with selected tributaries and emerging issues highlighted throughout the report.

The purpose of the report is to provide up-to-date information on the water quantity, quality and natural ecosystems of the Bow River Basin. Various influences on the overall health of the basin are also discussed, including hydroelectric generation, irrigation practices, industrial effluents, human and livestock population pressures, wastewater discharges, and other pollutants.

The report describes how these influences affect water users, including recreational uses, livestock watering, irrigation, and industrial use. An overview of jurisdictional responsibility for the management of the Bow River Basin system is presented, and current initiatives that address concerns and aim to improve the basin's management are identified. Specific reference is made to the relevance of the recently issued Water for Life: Alberta's Strategy for Sustainability.[128]

It is important that the management and use of the Bow River Basin are guided by reliable information. The BRBC's intention is to establish routine, credible status reports that will:

- Improve the public's overall understanding of the Bow River Basin through the analysis and interpretation of data, research and trends.
- Facilitate responsible decision-making regarding water issues in the Bow River Basin.
- Engage the general public, stakeholders and resource managers in discussion, and through these discussions, make meaningful recommendations for improvements to the basin's management.

This report will be used as a baseline from which to compare future changes and trends. Subsequent reports will update and improve upon the current document, noting challenges and successes in the continuing efforts to wisely manage the Bow River Basin.

1.2 Approach

The overall state of the Bow River Basin is determined by evaluating trends in four major areas:

- water quantity (hydrology)
- water quality
- natural ecosystems
- stewardship

In this report, water flows are quantified and water quality is assessed using various water quality indicators. Terrestrial, riparian, wetland, and aquatic habitats are described, as are land uses and human population distributions within the basin. Where available, tributary information is discussed.

Data is presented in graphic and tabular format and interpreted in the text, identifying key temporal and spatial changes. Where sufficient information exists, sources of change or modifications to the natural state are suggested. Geographic Information Systems (GIS) are also used for interpretation and analysis of spatial data. Stewardship is described through examples of programs and organizations at work throughout the basin.

Chapter 2 summarizes basin-wide characteristics, while Chapters 3 through 10 describe each reach in more detail. Following the practice used by Alberta Environment, the report divides the river into eight individual reaches based on local landmarks (Table 1.1 and Figure 1.1). Though the word reach refers specifically to the river itself, this report uses the word to also include the surrounding watershed, including the landbase, land uses and other water features that influence and are influenced by the river. Most reaches begin just above a confluence and end just above the next confluence. Information in this report is presented in geographic sequence from the headwaters of the river to its mouth, where the confluence of the Bow and Oldman rivers forms the South Saskatchewan River.

No new sampling was conducted nor was any new data generated for this report. Rather, the assessment of the Bow River Basin is based on existing literature and data collected mainly between 1991 and 2003. The lag time between 2003 and the publication date is a result of the time required for a variety of agencies to assemble, organize, verify, and interpret the data, as well as identify relationships and trends. More recent data are included where available.

Figure 1.1 Reaches of the Bow River Basin[39]

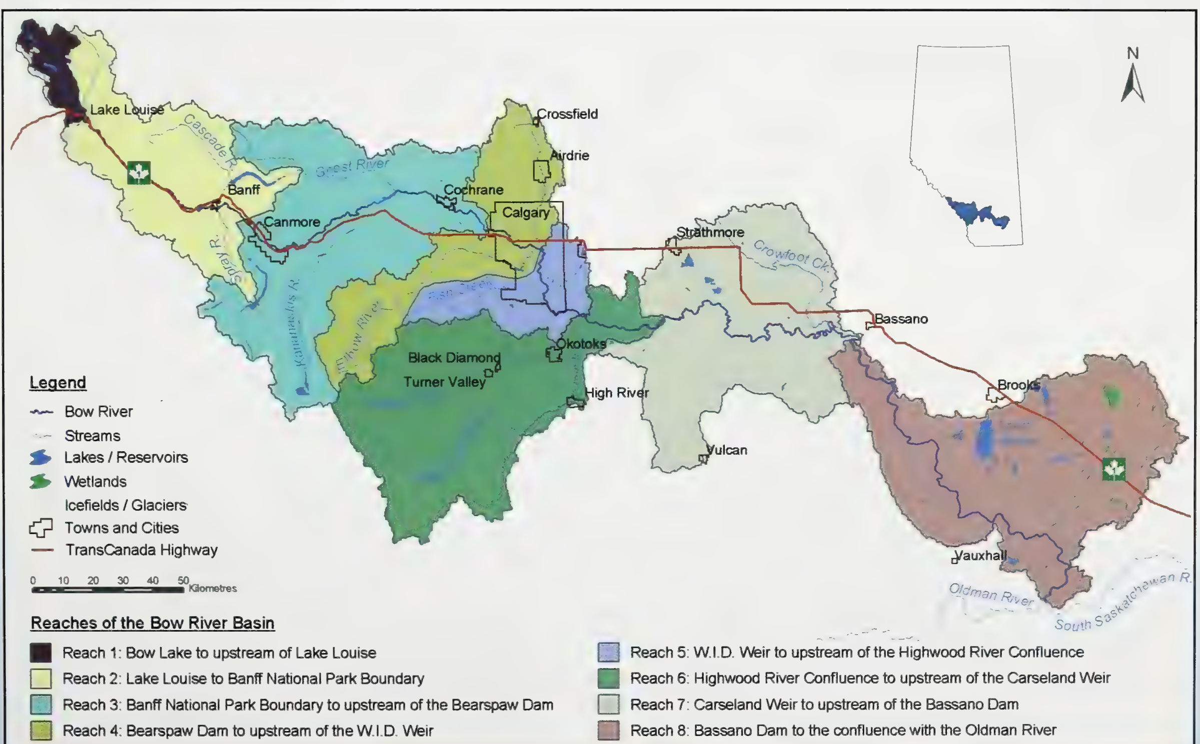


Table 1.1 Reaches of the Bow River Basin

Reach	Boundaries of Reach	Area (km^2)	Length (km)
1	Bow Lake to upstream of Lake Louise	418	51
2	Lake Louise to Banff National Park Boundary	2,843	82
3	Banff National Park Boundary to upstream of the Bearspaw Dam	4,453	117
4	Bearspaw Dam to upstream of the Western Irrigation District Weir	2,363	23
5	WID Weir to upstream of the Highwood River Confluence[a b]	1,137	42
6	Highwood River Confluence to upstream of the Carseland Weir[a]	4,387	34
7	Carseland Weir to upstream of the Bassano Dam[c]	4,291	126
8	Bassano Dam to the confluence with the Oldman River [d]	5,231	170
Total Bow River Basin		**25,123**	**645**[e]

[a] The boundaries of these two reaches have changed slightly from the 1994 State of the Basin Report to be consistent with Alberta Environment boundaries

[b] Includes the Western Irrigation District (WID) and water use through the works of the WID

[c] Includes the Bow River Irrigation District (BRID) and water use through the works of the BRID

[d] Includes the Eastern Irrigation District (EID) and water use through the works of the EID

[e] Discrepancies in the lengths of the reaches can be expected, as the river meanders and changes over time

In general, quantitative data are assessed for the mainstem of the Bow River; qualitative (descriptive) data are used in the discussion of the major tributaries.

Although this report has referenced many scientific articles and reports, it is not specifically intended for a technical or scientific audience. It has been written for an informed, interested public. Resources and publications are listed at the end of the report for those wanting additional information and detail not provided in this overview. Some of the data acquired and used in the assessment of the basin are available on CD (on request to the BRBC).

1.3 Hydrology

Hydrology is one of the primary components of a river basin's characteristics. Streamflows influence many physical attributes of the river system, including channel type and depth (channel morphology) and the expanse of riparian, wetland and aquatic habitat. The volume and intensity of river flows also affect water quality. The quantity and velocity of the river's flow determines, in part, the concentration of substances in the water, erosion and deposition rates, water temperatures, and the biological productivity of the system. As a result, it influences the aquatic ecosystem and determines the plant and animal life it supports.

The quantity of water flowing through the basin varies greatly along its length and during different seasons. Precipitation, glacier melt, surface runoff, and groundwater all contribute to the flows of the river. Flows are generally greatest during the spring, when melting snow and ice in the headwaters add to the quantity in the river, and are lowest during the winter season. Inputs from tributaries and runoff from the landbase provide water to the mainstem of the river, increasing flows along its length. Human influences can add to the flows through discharges (e.g. municipal wastewaters), or subtract from them, in the form of withdrawals (e.g. irrigation diversions).

Water flows are measured in cubic metres per second (m^3/s). These units represent the volume of water that passes through a point on the river in one second's time. Flows can also be represented in a hydrograph, which is a graph depicting the average flows for every day of the year (Figure 1.2). Both recorded flows and natural flows of the Bow River are described in this report, using a dataset that spans the years 1971 to 2001. Recorded flows are the actual flows measured at hydrometric monitoring stations along the Bow River. Natural flows are calculated from a model that determines what the flow would have been without any of the regulation, withdrawals, diversions, and discharges that actually occur along the basin. The recorded hydrograph data are often incomplete, missing data for various seasons or years, while the modelled natural flows may be more complete.

Hydrometric information is presented for eight locations along the Bow River (Figure 1.3), providing a long-term record of changes in flow in the basin. Some locations described in the report do not have a hydrometric station; flows at these locations are estimated or calculated from stations at other locations. In this report, flows are described only for the mainstem of the Bow River, and not the tributaries.

Recorded flows were provided by both Environment Canada and Alberta Environment;[108] Alberta Environment provided the natural flow data.[29]

Water uses that affect flows, such as hydroelectric generation and irrigation, are discussed in Chapter 2. Reach-specific flow information is discussed in Chapters 3 through 10.

Figure 1.2 Example of a hydrograph showing natural and recorded flows [29]

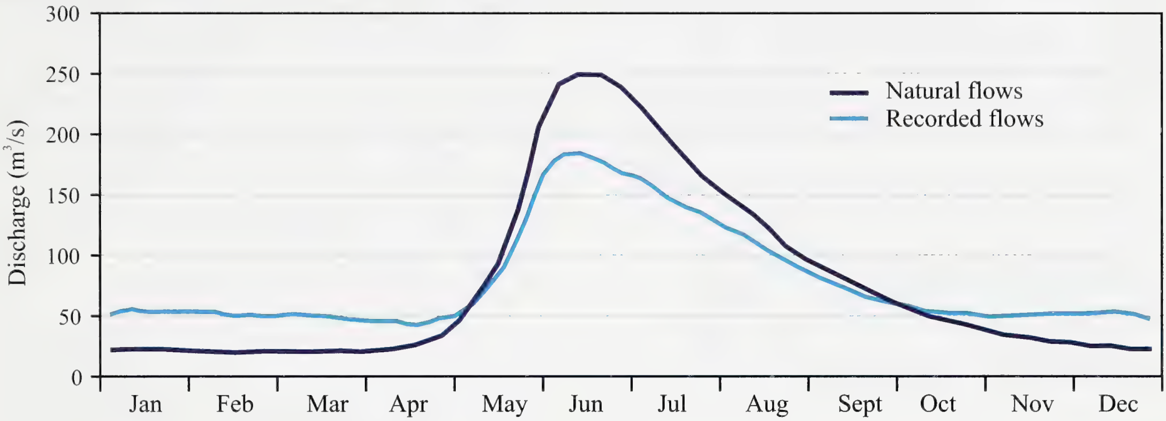
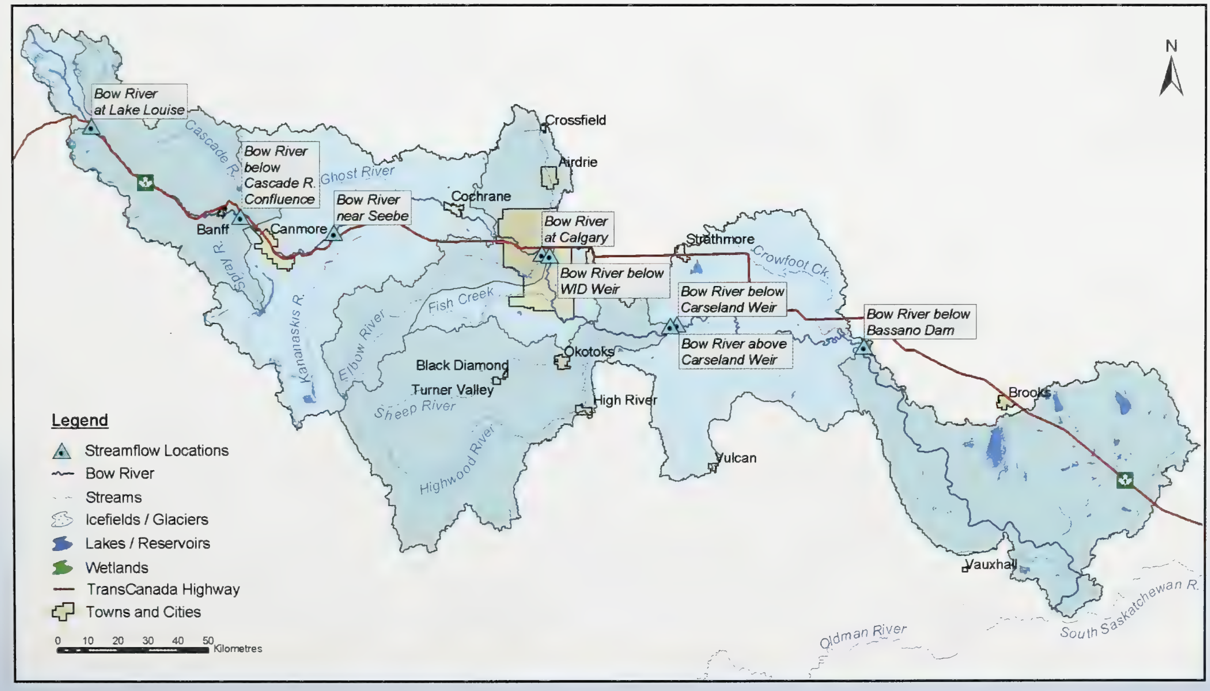


Figure 1.3 Streamflow measuring locations in the Bow River Basin[39 195]



Water Allocation Tables

In order to discuss the impacts of water use on the Bow River Basin, water licensing information was assessed. Water allocation within the Bow River Basin was determined by Alberta Environment from 2002 licence data. Licensing information is available for Reaches 3 to 8, and is regulated by Alberta Environment. The federal government issues licences for water use within Reaches 1 and 2, but this information was not available for this report.

Tables 1.2 and 1.3 provide examples of how this information was presented for each reach. Water licences were organized into four categories:

- **Industry:** oilfield injection, oil and gas plants, food processing, and aggregate washing
- **Irrigation/agriculture:** irrigation districts, private irrigators, livestock watering, fish farms, and tree farms
- **Municipal:** cities, towns, villages, schools, recreation centres, fire protection systems, residential sub-divisions, and water co-operatives
- **Other:** golf courses, parks, water management, waterfowl projects, household, and storage purposes

The percentage of the average annual natural flow within each reach allocated to all licences within that reach was calculated to show the impact of these withdrawals on flows of the Bow River within that reach (Table 1.2).

The water use information associated with each licence was also organized into several categories:

- **Licensed allocation** is the maximum amount of water that a licensee is permitted to divert from a water body. Water allocations from Alberta Environment outline the volume, rate, timing, and any restrictions for the diversion of water. It is the sum of the licensed consumption and licensed return flows (Table 1.2).
- **Licensed consumption** is the amount of water the licence holder is permitted to divert that is not entirely or directly returned to a water body. It includes seepage and other losses within the system (Table 1.3).
- **Estimated consumption** is the approximate amount of water actually diverted by each licensee that is not entirely or directly returned to the water body (Table 1.3).
- **Licensed return flow** is the amount of water licensed for return to a water body after withdrawal. Water can be withdrawn from one water body and returned to another, sometimes to one in a different sub-basin. Return flows may also include drainage water from surface runoff or shallow groundwater discharge (Table 1.3).
- **Estimated return flow** is the approximate amount of water actually returned to a water body after withdrawal by each licensee (Table 1.3).

The estimated consumption and return flow information in the water allocation tables is dependent on the records kept and submitted by each licensee. When water use reports for each licence are absent, the licensed consumption and licensed return flows are used to approximate the estimated consumption and return flows, respectively. This probably overestimates the estimated consumption and return flow data.

It is also important to note that the water allocation tables are organized by licences within each reach. The total allocation, consumption and return flows for each licensee are included in the same table. While this allows a clear comparison of how much water used by the licensees is consumed and returned to the Bow River, it presents a complicated picture of actual water flows within the reach. For example, some of the licensees withdraw water from the Bow River in one reach, but return it in another reach. In this situation, the water use table for the reach where the water is

Table 1.2 Example of a licensed allocation table (Bow River in Reach 7)[193 108]

Water User	Annual Licensed Allocation (m^3)	Percentage of Annual Average Bow River Discharge (%)
Industrial	3,198,400	0.08
Irrigation & Agriculture	563,829,493	14.27
Municipal	1,899,800	0.04
Other	262,384	< 0.01
Total	**569,190,077**	**14.41**

Table 1.3 Example of licensed and estimated annual consumption and returns (Bow River in Reach 7)[193]

Water User	Annual Consumption from the Bow River (m^3)		Annual Return Flows to the Bow River (m^3)	
	Licensed	Estimated[a]	Licensed	Estimated[a]
Industrial	3,198,400	1,228,075	0	0
Irrigation & Agriculture	440,481,293	327,544,873	123,348,200	78,449,445
Municipal	1,070,882	766,222	828,918	223,270
Other	262,384	262,384	0	0
Total	**445,012,959**	**329,801,554**	**124,177,118**	**78,672,715**

[a] When water use reports for each license are absent, the licensed consumption and licensed return flows are used to approximate the estimated consumption and return flows, respectively. This likely overestimates the estimated consumption and return flow data in this reach.

withdrawn includes the return flows that occur in another reach; the water use table for the reach where the water is returned does not show this return flow information.

This issue becomes most apparent in the mid and lower reaches of the Bow River, where the majority of water withdrawals are part of larger diversion projects. The City of Calgary, for example, withdraws water from the Bow River in Reach 4, but returns it in Reach 5. The Western Irrigation District (WID) withdraws water from Reach 5, but returns the majority of it in Reach 7. The Bow River Irrigation District (BRID) withdraws water from Reach 7, but returns it in Reach 8. To complicate things further, the WID returns some of this water outside the Bow River Basin to the Red Deer River Basin, and the BRID returns some of its water to the Oldman River Basin. The Eastern Irrigation District (EID) both withdraws and returns flows to Reach 8 of the Bow River, but some return flows go to the Red Deer River Basin. Because the Bow, Red Deer and Oldman rivers are all part of the South Saskatchewan River Basin, these return flows are considered sub-basin transfers. These transfers are not included in the return flow information in Table 1.3.

Another feature of the water use tables is that they only include allocations for the mainstem of the Bow River. Licensing information from the tributaries of the Bow River or from groundwater is not included, although it can significantly influence the flows of the Bow River. Recommendations to simplify and clarify the collection and presentation of water use in future State of the Bow River Basin Reports are included in Chapter 12.

Bassano Dam – PFRA

1.4 Water Quality

The water quality of a river is often considered a general reflection of its health. Quantitative assessments of water quality are determined by measuring physical (e.g. temperature, turbidity), chemical (e.g. dissolved oxygen, nutrients) and biological (e.g. bacteria) characteristics of the water. Like water quantity, the quality of water flowing through a basin varies longitudinally and seasonally. It is affected by natural factors such as the geology of the river basin, the vegetation of the watershed, the materials carried in surface runoff, and the inputs from precipitation, glacier melt, surface runoff, groundwater, and tributaries.

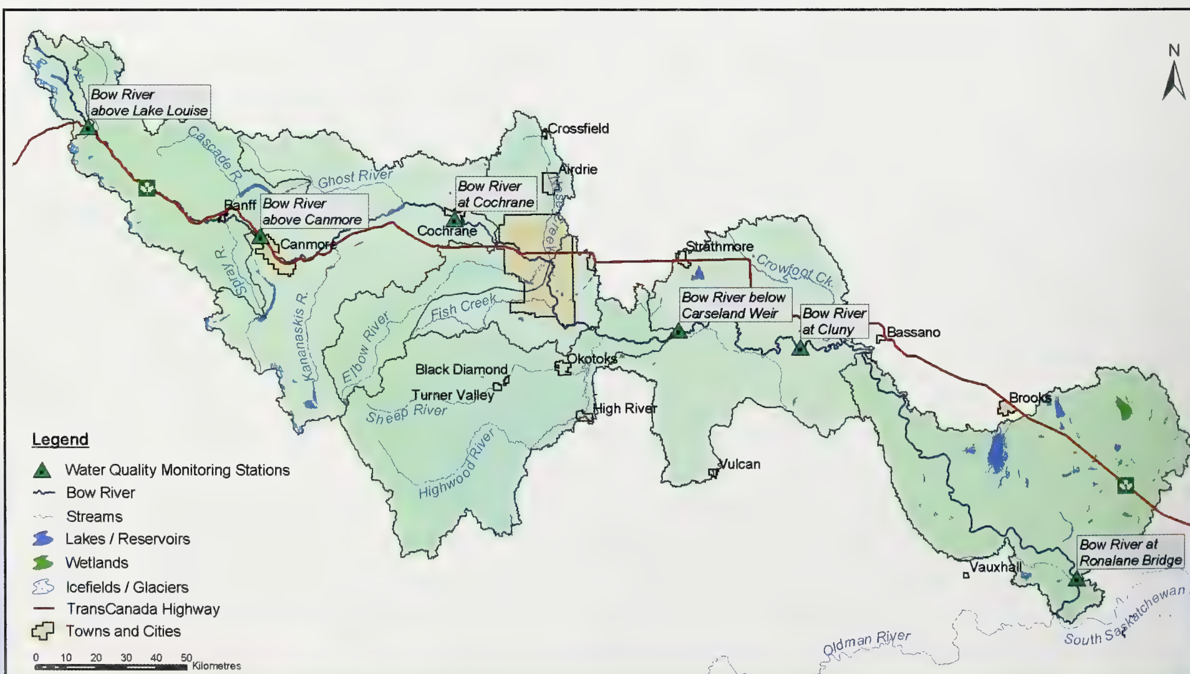
Along with streamflows, the water quality of the river determines the structure and productivity of aquatic plant and animal communities. The plant and animal communities, in turn, influence water quality, such as the amount of oxygen, organic material, nutrients, and bacteria in the water. Other influences on water quality include human activities (e.g. effluent quality discharged from municipalities and industries).

Traditional reports on water quality typically consist of complex statistical analyses and summaries of many individual variables. This type of information is of value to water quality experts, but may not be meaningful to an interested public who wants to know about the state of the Bow River Basin, or managers and policy makers who require concise information.

Alternatively, key variables, or indicators, can be used to highlight the most important aspects of water quality in terms of human use and aquatic ecosystem requirements. These indicators can be incorporated into a Water Quality Index (WQI), which summarizes large amounts of water quality data into simple and consistent terms. Similar to the UV index or an air quality index, it can indicate whether the overall water quality poses a potential threat to various uses of the water and provides a rating on a scale from 100 (excellent) to 0 (poor).[32 67] Through the use of this index, detail is sacrificed for simplicity and comparability throughout the basin and with other watersheds. The WQI used in this report is described in more detail on the next page.

Water quality information has been presented at four of Alberta Environment's long-term river network stations along the Bow River (Figure 1.4), providing a long-term record of changes along the basin.[27] Reaches 1, 2, 4 and 5 lack sufficient long-term water quality monitoring data required to calculate comparable WQIs.[120] For these reaches, existing reports and

Figure 1.4 Water quality monitoring stations along the Bow River Basin[23 39]



information from several monitoring stations were used to describe the water quality. Synoptic surveys were also used to describe water quality changes along the length of the Bow River.[219, 249] These surveys follow a unit of water as it flows from the upper end of the basin to the mouth, documenting changes and inputs along the river's length due to natural and human influences.

For this report, only the water quality of the mainstem of the Bow River is assessed in detail. Where appropriate, water quality of the tributaries is described using qualitative information from existing reports. Major tributary influences on the water quality of the mainstem of the Bow River are also discussed. Human activities and water uses that affect water quality, such as irrigation and municipal wastewaters, are discussed in Chapter 2. A summary of the water quality of the Bow River is also found in Chapter 2; reach-specific information is discussed in Chapters 3 through 10.

Water Quality Index

The Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI), as calculated by Alberta Environment, was used to assess water quality along the Bow River. The WQI provides a consistent procedure to report water quality information and has been used in Alberta, British Columbia, Manitoba, Newfoundland, and Québec.

Water quality variables included in the index (Table 1.4) were compared to water quality guidelines.[31, 66] These guidelines are set to protect recreational users, aesthetics, aquatic life, and agricultural users (livestock watering and crop production). While it may seem important to compare the water quality of the Bow River with drinking water guidelines, this approach is inappropriate for surface waters.

Drinking water guidelines apply only to treated water provided by municipal distribution systems, and therefore are not discussed in this report. Because water quality guidelines are not available for many pesticides, the presence or absence of detectable pesticide levels was used as a surrogate. Detection limits are kept consistent over time to prevent changes in detection limits from influencing the presence or absence of detectable data.

The variable data and relevant water quality guidelines for each sampling site were then applied to the WQI formula, which is based on three measures:

- **Scope:** the number of variables not meeting water quality guidelines.
- **Frequency:** the number of samples in which these guidelines are not met.
- **Amplitude:** the amount by which the guidelines are not met.

The WQI calculates a number between 0 (worst water quality) and 100 (best water quality) for each sampling site. The WQI is then reported according to five descriptive categories:[67]

- **Excellent:** values from 95 - 100, water quality is protected with a virtual absence of threat or impairment; conditions rarely depart from natural or desirable levels. In Figure 1.5 (page 13), the extent of the graph's background that is "excellent" is coloured blue.
- **Good:** values from 80 - 94, water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels. The portion of Figure 1.5 that is "good" is coloured green.
- **Fair:** values from 65 - 79, water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels The portion of Figure 1.5 that is "fair" is coloured yellow.

Table 1.4 Water quality variables used to calculate the WQI[27]

Water Quality Variable	Description and Importance
Nutrients and Aquatic Life	
Total Nitrogen	Nitrogen is an essential nutrient for productivity of the aquatic system. Total nitrogen is the sum of the different forms found naturally in the water, including nitrate, nitrite and ammonia. Nitrogen enters surface waters naturally through the air and surface runoff, or through human activities such as wastewater discharges and agricultural practices. Elevated concentrations can result in the excessive growth of algae and aquatic plants.
Total Ammonia	Ammonia is a form of nitrogen produced by the decomposition of organic material. If found in water, ammonia can be highly toxic to aquatic organisms. In most well-oxygenated waters, ammonia is converted quickly to non-toxic nitrate, a nutrient necessary for plant growth. Ammonia can be discharged by municipal and industrial wastewater effluents.
Nitrite	Nitrite is a dissolved inorganic form of nitrogen. Sources of nitrite include surface runoff, rain, municipal and industrial effluents, and soil leaching. Surface waters generally contain low concentrations of nitrite, since it is quickly converted to nitrate in well-oxygenated water. High concentrations of nitrite can pose a toxic risk for livestock watering.
Total Phosphorus	Phosphorus is another nutrient essential for aquatic plant growth. Total phosphorus includes particulate as well as dissolved phosphorus, however, it is the latter form that is most readily bio-available for plant growth. Phosphorus enters surface waters naturally through runoff, or through human activities such as wastewater discharges and agricultural practices. Elevated concentrations can result in excessive growth of algae and aquatic plants.
Dissolved Oxygen	Sufficient dissolved oxygen (DO) concentrations are essential for the survival of most aquatic life forms. With increasing water temperature, the solubility of oxygen decreases. At the same time, however, the respiratory requirements of aquatic organisms increase. Decomposition of excessive organic material can also decrease DO concentrations to the point where fish die.
pH	pH is the concentration of hydrogen ions in the water (pH of 7 is neutral, above 7 is basic and below 7 is acidic). pH influences the toxicity of metals, particularly aluminum and iron. At more acidic pH levels, these metals are significantly more toxic.
Bacteria	
Fecal Coliforms	Fecal coliform bacteria are found in the guts of mammals. They can enter surface waters through fecal contamination by wildlife and domestic animals. They can also enter surface waters through wastewater discharges or surface water runoff. Fecal coliform bacteria are not necessarily harmful to human health, but they indicate the possible presence of other pathogenic organisms, including *E. coli*, *Salmonella*, *Giardia* and *Cryptosporidium*, which can have serious health implications.
Escherichia coli	*E. coli* is a type of fecal coliform bacteria. Most *E. coli* are harmless but several strains (including the 0157:H7 strain) can be toxic and cause severe gastrointestinal illness if contaminated water is ingested.
Metals	
Silver, aluminum, arsenic, barium, boron, beryllium, cadmium, cobalt, copper, iron, mercury, lithium, manganese, molybdenum, nickel, lead, selenium, titanium, uranium, vanadium, zinc, cyanide	High concentrations of metals can be toxic to aquatic organisms. They can enter surface waters naturally, through weathering and runoff, but are also discharged in wastewater effluents.
Pesticides	
2,4-D, MCPP, MCPA, diazinon, lindane, picloram, dicamba, triallate, atrazine, bromoxynil, cyanizine, malathion, methoxychlor, chlorpyrifos imazamethabenz, diuron, dichlorprop	High concentrations of pesticides can be toxic to aquatic organisms and watered livestock. Pesticides can enter surface waters via runoff from municipal or agricultural land applications. Pesticides leaching through soils can contaminate groundwater.

- **Marginal:** values from 45 - 64, water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels. The portion of Figure 1.5 that is "marginal" is coloured orange.
- **Poor:** values from 0 - 44, water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels. The portion of Figure 1.5 that is "poor" is coloured red.

Alberta Environment has calculated WQIs for Reaches 3, 6, 7, and 8 using four indicator groups (nutrients, bacteria, metals, and pesticides). These results are then averaged, to provide an overall WQI rating for each sampling site. The water quality monitoring programs vary at each site along the Bow River, in terms of variables measured and their sampling frequency. Only the water quality variables with sufficient information are included in the WQI for each site.

Graphs have been generated to show the trends over time for each sampling site. The WQIs show relative differences in water quality over time and can also indicate relative differences in water quality within a reach or along the Bow River. Because the WQIs use the same variable sets and water quality guidelines, the results for these four sites are comparable.

In Figure 1.5, the four different coloured lines (green, grey, pink and blue) represent the Alberta Environment WQI results for nutrients, pesticides, metals, and bacteria variable groups. The black line represents the average WQI result of these four variable groups. The results have been generated annually for the years 1990/1991 through 2000/2001, and the changes over time can be read along the horizontal axis. The vertical axis is the range of WQI descriptive categories as described above.

1.5 Ecosystems

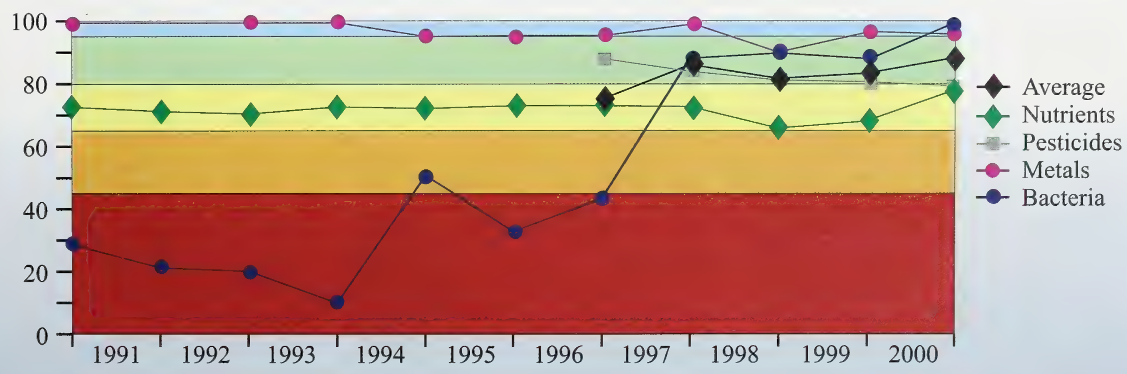
The natural ecosystems of the Bow River Basin can be viewed as functional units of the landscape, composed of biological communities interacting with the physical environment. Natural processes and interactions link these watershed components that together transport sediment, water and energy, generate new floodplains and channels, and sustain biological communities. The water quantity and quality of a watershed are determined by the combined influences of its water sources (e.g. precipitation, glacier melt, surface runoff, groundwater), flowing waters (e.g. rivers, streams, riparian zones), still waters (e.g. lakes, wetlands), and upland areas.

While quantitative ecological data exists for the plants and animals in the Bow River Basin, for the purposes of this report the ecosystems of the Bow River Basin are best assessed by describing general terrestrial information, with a focus on the riparian (near-shore vegetation), wetland and aquatic habitats. The vegetation communities, wildlife and fish populations that are supported by these habitats are also described.

To a large extent, the abundance, diversity and geographic extent of wildlife within the Bow River Basin are dependent on the quality and quantity of riparian and wetland habitat. The populations, diversity, distribution, and health of aquatic plants, benthic invertebrates and fish are dependent on water availability, water quality of the river and its tributaries and the quality and quantity of riparian habitat. The wetland and channel habitat created by the irrigation canals and drainage systems are also included, as they too provide important habitat within the basin.

A variety of information sources was used to collect the information and document the ecosystem status of the Bow River Basin. Several reports have already assessed ecosystem components along the length of the

Figure 1.5 Example of a water quality index graph[27]



Bow River, using a variety of approaches. Alberta Environment's Strategic Overview of Riparian and Aquatic Condition of the South Saskatchewan River Basin[123] was used to describe the Bow River Basin, in conjunction with the Alberta Riparian Habitat Management Program – Cows and Fish report on the South Saskatchewan River Basin Riparian Health.[38]

The General Status of Alberta Wild Species was used to highlight those species that are currently vulnerable or at risk due to habitat loss or other pressures on their populations within the basin.[44]

The ecosystem is described on a basin-wide basis in Chapter 2, while individual reaches are assessed in Chapters 3 to 10. Within the terrestrial, riparian, wetland, and aquatic habitats, information on the relevant vegetation, wildlife, benthic invertebrates, and fish populations include the following:

- common species and their relative abundance and distribution
- critical habitats and life stage utilization
- protected status and vulnerability
- human influences

When assessing the ecosystems within a watershed and river system, it is important to note that their plant and animal populations are subject to a wide range of natural variation. Biological cycles, reproductive rates and climatic and seasonal variation all lead to natural changes in population levels. As such, care must be taken when suggesting that trends and changes over time fall outside the natural range. This report has taken a conservative approach when describing population level changes, however, impacts and influences on the natural ecosystems of the Bow River Basin are identified when supported by the literature.

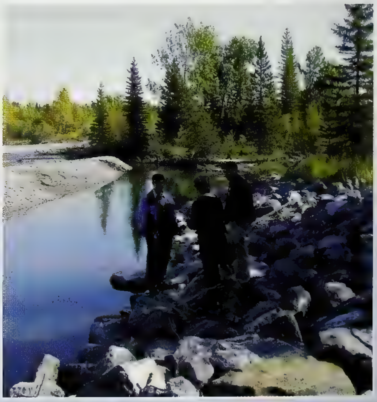
1.6 Stewardship

Stewardship of the Bow River Basin is given greater prominence in the current State of the Bow River Basin Report. Stewardship groups, federal, provincial and municipal governments, academic institutions, non-government organizations, and industries in the basin have undertaken various initiatives to improve the management and protection of the basin's resources. These initiatives include restoration projects, implementation of efficiencies and improved technologies, monitoring programs, web-based provision of data and information transfer, public education initiatives, and participation in government-sponsored advisory boards on basin-related issues.

Such activities are critical to achieving stakeholder-identified management goals. For management plans and instream objectives to have positive impacts on the Bow River Basin, governments, organizations and individuals must take responsibility for ensuring the implementation of long-term monitoring programs. Through these programs, the successes and failures of the management plans and instream objectives may be identified. As a result, current basin management practices may be improved and modified to effect positive changes and possibly avoid further pressures on the resources of the basin.

This report discusses the activities and efforts currently being undertaken to improve the state of the Bow River Basin and presents enhanced opportunities for watershed management. While it is not possible to acknowledge all individuals and worthwhile programs, several organizations and programs responsible for stewardship initiatives are described throughout Chapters 3 to 11 in this report. Stewardship groups that are active within certain reaches are reported in the relevant reach-specific chapter, while those that operate throughout the basin are described in Chapter 11.

R.Phillips



BRBC

Chapter 2

Bow River in Banff National Park – A.MacKeigan

Chapter 2

The Bow River Basin – General Overview

2.1 Introduction

This chapter gives a general overview of the Bow River Basin, including its geography, climate, hydrology, water quality, natural environment, and human population. The chapter also outlines the major human activities in the basin, such as hydroelectric generation, irrigation, agriculture, and urbanization. The impacts of these activities and influences on the land and water resources of the Bow River Basin, including water quality, are summarized here. Details are given in the chapters on the individual reaches (Chapters 3 to 10). Issues that deal with management of the Bow River Basin, including inter-provincial agreements, licensing users and determination of the timing and quantities that constitute appropriate use are described at the end of this chapter.

2.2 Geography

The headwaters of the Bow River Basin originate from the snowpack and glacial ice of the Rocky Mountains along the Alberta (eastern) side of the Continental Divide. The Bow River originates in Bow Lake and flows in a southeasterly direction through Banff National Park (BNP) and its steep valley corridor. Exiting BNP, the river continues eastward and passes through the foothills onto the prairie. The Bow River gradually widens and decreases in gradient through the basin. It meanders through a wide, deep valley across the prairies toward its confluence with the Oldman River. The meeting of the Bow and Oldman Rivers creates the South Saskatchewan River, which is the southwest tributary of the Saskatchewan-Nelson River system that eventually flows to the Hudson Bay and the Arctic and Atlantic Oceans.

From headwaters to mouth, the Bow River flows for 645 km. The basin changes from an elevation of 3,400 metres (m) at the continental divide to 740 m above sea level at the confluence with the Oldman River, a drop of 2,600 m. The drainage basin of the Bow River is approximately 25,123 square kilometres (km^2), accounting for about 23% of the entire drainage area of the South Saskatchewan River.[123] The Bow River contributes nearly 43% of the 9,500 million cubic metres (m^3) average annual combined flows of the South Saskatchewan River, making it the largest tributary of that river system.[57]

2.3 Climate

The Bow River Basin exhibits the typical continental climate of southern Alberta, with long cold winters and short, warm summers (Table 2.1). The mountainous areas have colder winters and cooler summers than the prairies. The chinook, a warm, dry wind that occasionally blows across the mountains onto the foothills and prairies, can have a short-term, but dramatic influence on climate. During the winter, temperatures can rise by as much as 30 degrees Celsius (°C) within a few hours, while the humidity can drop more than 40%.[110]

Annual precipitation declines substantially from west to east. In the mountains, a high proportion of precipitation falls as snow, while rainfall accounts for the majority of the precipitation across the prairies.

Table 2.1 Climate conditions in the Bow River Basin[110]

Weather Station	Average Monthly Temperature (°C)		Average Annual Precipitation			Average Frost-Free Days per Year
	January	July	Rainfall (mm)	Snowfall (cm)	Total Precipitation (mm)	
Lake Louise	-14	12	265	304	569	97
Calgary	-9	16	321	127	413	169
Medicine Hat[a]	-10	20	250	95	334	189

[a] Medicine Hat is located just outside the southeast portion of the Bow River Basin in the South Saskatchewan River Basin

2.4 Hydrology

The majority of the flows of the Bow River are supplied by precipitation falling in the Rocky Mountains. Much of this precipitation accumulates in the snowpack during the winter and provides water to the river as it melts over the spring and summer. Warm winters or winters with little snowfall in the mountains can reduce the flows of the Bow River to below average for the rest of the season. Winters with high snowfall can result in spring and summer flooding, particularly if the snowmelt occurs rapidly during a warm spring. The snowpack in the foothills and prairies is reduced by chinook winds during the winter.

Runoff from these areas generally begins earlier in the spring and forms only a small portion of the total spring runoff. The major spring peak and most of the annual volume originates from the progressive melting of snow in the mountains. As glaciers in the upper elevations slowly melt, they provide additional runoff to the river in late summer and early fall.[257]

Groundwater contributes to the flows of the Bow River and is an important source, particularly during low flows.[136] Many tributaries add to the natural flows of the mainstem of the Bow River as it travels from the headwaters to the mouth (Figure 2.1 and Table 2.2).

The Bow River is a snowmelt river; its natural seasonal pattern is shown in Figure 2.2. A series of peak flows occur during the spring and summer, corresponding to the progressive melting of the snowpacks at low, moderate and high elevations. Flows decline over the late summer, fall and winter. Glacial melt contributes to the flows during the late summer and early fall, while the baseflows during the winter consist primarily of groundwater. As the flows increase during the next snowmelt, the cycle begins again. Peak discharges generally occur during June, with minimum flows in January. The progressive increase in streamflow along the length of the basin can also be seen in Figure 2.2.

While streamflows upstream of Banff can be considered relatively unchanged, most of the Bow River is highly altered from its natural flows. Figure 2.2 shows the natural flows of the Bow River along the length of the basin, while Figure 2.3 shows the actual recorded flows at these same sites. A comparison of these figures demonstrates that no differences exist in the two upper reaches, but the recorded flows in the lower reaches exhibit substantial seasonal differences from the natural flows. Summer flows are much lower, while winter flows have increased.

Figure 2.1 Major tributaries to the Bow River[39 195]

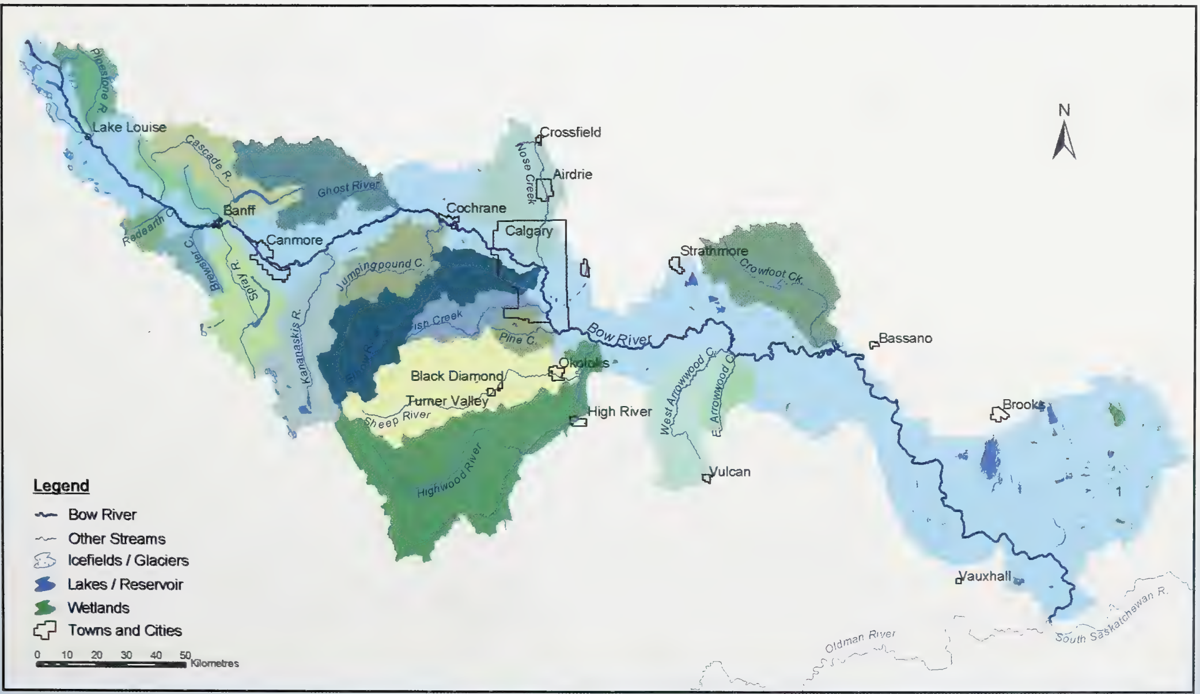


Table 2.2 Major tributaries to the Bow River[29]

River System		Length (km)	Area (km^2)	Average Annual Natural Discharge near Mouth (m^3)	Average Annual Recorded Discharge near Mouth (m^3)
Bow River Basin		645	25,123	3,950,494,237	2,776,707,927
Tributaries to the Bow River	**Reach**	**Length (km)**	**Area (km^2)**	**Average Annual Natural Discharge near Mouth (m^3)**	**Average Annual Recorded Discharge near Mouth (m^3)**
Pipestone River	2	42	306	No Data	No Data
Spray River	2	66	788	443,209,150	250,238,461
Cascade River	2	63	717	231,456,114	No Data
Kananaskis River	3	67	926	479,004,383	484,335,392
Ghost River	3	74	947	228,946,339	199,472,763
Elbow River	4	124	1,235	298,594,168	246,920,355
Nose Creek	4	73	979	No Data	No Data
Fish Creek	5	93	439	No Data	27,004,732
Sheep River*	6	107	1,573	257,852,098	217,975,298
Highwood River	6	162	2,412	702,152,769	571,525,594
Crowfoot Creek	7	141	1,438	No Data	39,513,773

* The Sheep River is a tributary of the Highwood, not the Bow River, but is included in this table as it drains a large landbase and is a significant stream within the Bow River Basin.

Of particular note are the spring, summer and fall flows of the river below the Bassano Dam, which are significantly lower than natural flows. Hydroelectric facilities, water withdrawals, diversions, irrigation canals, and wastewater discharges all contribute to these changes to the natural flows of the Bow River. Approximately 40% of the basin's total annual natural flows are altered, making the Bow River the most regulated river in Alberta.[90]

While there are no large water diversions from the river above Calgary, withdrawals by several municipalities and industries modify flow patterns in the river's upper reaches. The section of the river from Banff to the Bearspaw Dam exhibits substantial seasonal change and daily flow fluctuations due to hydroelectric development. The number of hydroelectric dams and their locations on the Bow River are listed in Table 2.4, page 23.

The Bearspaw Dam re-regulates the river, reducing the daily fluctuations and variations that are observed upstream. Hydroelectric power generation is not considered a consumptive use of the river, as nearly all the water stored eventually makes its way downstream.

Three on-stream water diversions, the other major influence on the river's hydrology, are found between Calgary and the confluence with the Oldman River. The Western Irrigation District (WID) weir is located within Calgary, the Bow River Irrigation District (BRID) weir is located at Carseland and the Eastern Irrigation District (EID) dam is located at Bassano.

These structures divert water from the Bow River and decrease flows downstream, but some of the water is returned to the river through the irrigation canal systems. However, the network of canals results in some of the water being returned to the Oldman and Red Deer river systems, rather than to the Bow River, thus a significantly-reduced portion of the irrigation diversions from the Bow River are returned.

Within the WID, much of the return flows enter the Red Deer River via Serviceberry Creek and the Rosebud River. Water taken from the Highwood River at High River is transferred via the Mosquito Creek, Frank Lake and Little Bow irrigation diversion into the Little Bow River, historically a part of the Oldman River Basin.

These waters combine with flows from the main BRID diversion from the Bow River. Return flows from the district enter both the Bow and Oldman Rivers. In the EID, much of the return flow drains to the Red Deer River, with little flow returning to the Bow River.

Overall, the Red Deer River is a major net beneficiary of the irrigation diversions from the Bow River. The Oldman River gains from diversion water taken from the Bow River, but loses a large portion of the historical spring flow from the Little Bow River. Ultimately, the flows from all these rivers merge to form the South Saskatchewan River system.

2.5 Water Quality

Water quality of the Bow River varies along its length, with more pronounced changes occurring downstream. Some of these changes are natural, while others are due to human activities within the basin. As water moves along the basin, increasing amounts of sediment, minerals, nutrients, and organic material are found.[249] As the river widens, the gradient decreases; as water is diverted from the river, flows become slower and water temperatures increase.

Figure 2.2 Natural flows along the Bow River (average from 1971 to 2001)[29]

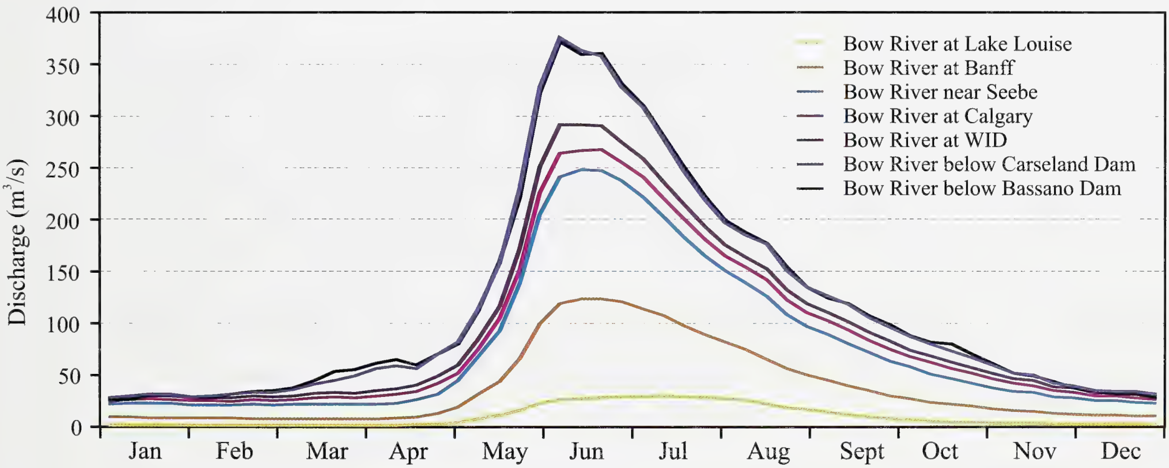
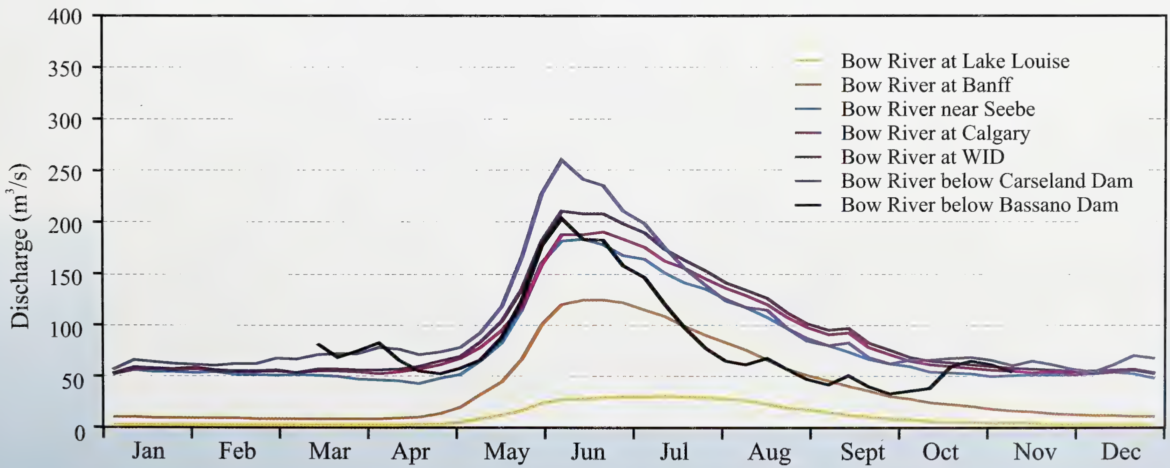


Figure 2.3 Recorded flows along the Bow River (average from 1971 to 2001)[29]



While the water quality at the headwaters of the river is generally excellent, it is not pristine. Glacial ice and water samples taken near the headwaters of the Bow River confirm the presence of several pesticides and persistent organic pollutants, including lindane, PCBs and DDT.[53] These compounds are present in fish found in Bow Lake,[64] which is fed primarily by glacial meltwater, demonstrating the impacts of long-range atmospheric transport and deposition of pollutants.

The emerald hue of Bow Lake and other alpine water bodies is caused by light reflection from very fine particles of rock that are ground loose and released naturally from the melting glaciers. Other than this glacial flour, the Bow River and its tributaries contain very low sediment levels near the headwaters, even during spring runoff.[109] Road construction and use, railroads, municipal effluents, cultivation, and natural runoff all increase the sediment loading to the Bow River as it flows through the basin.

The water chemistry of the Bow River is dominated by calcium, magnesium and bicarbonate ions. The pH is slightly alkaline, and the total hardness increases from low to moderate along the length of the river.[109] Natural weathering processes control these general chemical characteristics of the water.[249]

The upper Bow River and its tributaries contain few nutrients and are generally oligotrophic (have low biological productivity).[208] Along its length, nutrients are added to the river, increasing the productivity of the system. Impacts on the river's productivity have been observed as far upstream as Lake Louise and Banff.[50 58]

Algae and aquatic plants increase substantially downstream of the City of Calgary[216] due to municipal wastewater effluent and agricultural runoff.[249 65] Eutrophication (high biological productivity) problems appear to decrease downstream of Calgary near the mouth.[216] Bacterial concentrations in the Bow River are also linked to municipal discharges and agricultural runoff.[249 203]

Records of poor water quality date back to the early 1940s when fish caught from Calgary to the Highwood River confluence reportedly tasted oily.[133] Nuisance algal growth and high bacteria counts were also observed in the Bow River near Bassano during this time. These problems were attributed to untreated sewage discharges from the City of Calgary.[133] Following construction of the Bearspaw Dam, which increased minimum flows, and new wastewater treatment plants at Calgary, these problems were partially alleviated.

Increasing population growth and wastewater discharges in the next three decades offset these improvements. Low oxygen concentrations, high temperatures and high nutrient concentrations led to prolific aquatic weed growth, changes to benthic invertebrate communities and occasional fish kills downstream of Calgary during the 1960s and 1970s.[133] Since the 1980s, Lake Louise, Banff, Canmore, and Calgary have substantially improved their wastewater treatment. Upgrades have greatly reduced suspended solids, organic material, bacteria, and nutrient loading along the length of the Bow River.[73 203 208 216]

Moraine Lake – C.Coffey

How might climate change affect the Bow River?

Human influences on the atmosphere through increased releases of greenhouse gasses are predicted to result in climate change and a rise in the average global temperature. One scenario suggests that these changes could include shorter, warmer winters, and changes in precipitation (proportionately more rain and less snow).[138]

The Intergovernmental Panel on Climate Change, an international co-operative of the United Nations Environmental Program and the World Meteorological Organization, has recorded nearly one degree Celsius (°C) of global warming in the last century.[illegible] Climate stations in Alberta reflect this trend. Average annual temperatures across the prairies have increased in the last 50 years,[illegible] with Banff and Calgary warming almost 1°C in the last 65 years.[illegible] Higher minimum temperatures, rather than higher maximum temperatures, are the basis for this warming trend.[illegible] By the middle of this century, the prairie region is forecast to warm by 2 to 5 °C in one scenario.[61] In cold temperate climatic zones like the Bow River Basin, this may result in changes to the timing of streamflows. A smaller proportion of precipitation would fall as snow, resulting in smaller snowpack accumulated over the winter.[illegible] With less snow available for melting, runoff and streamflows would decrease during the spring. The natural snowmelt regime of the Bow River may therefore decline to a modest runoff peak earlier in the spring. Streamflows would increase during the winter, as proportionately more of the winter's precipitation would fall as rain.[138 61]

Predicted changes to glaciers may also influence flows of the Bow River. Glacial meltwater contributes only about 2.5% of the total annual flow in the Bow River upstream of Banff, but in low flow years, it can contribute up to 16%.[illegible] During the summer months, these contributions are about 7% during average flow years, but in the lowest flow year (1970), 47% of the August flows upstream of Banff came from glacial meltwater.[illegible] Over the last few decades, glaciers in the Bow River Basin have been receding.[illegible] If this increased melting rate were to continue, increased flows would be expected during the summer. However, if the glaciers continued to retreat, less meltwater would be available over time to supplement streamflows during the summer.[illegible] This source of water, increasingly important during years of drought, may therefore be in decline in the Bow River Basin.[illegible] These cumulative changes in source waters may result in small changes in flow in typical years, but substantial declines in drought years.[206]

These potential impacts on streamflows of the Bow River have implications for economic, societal and industrial sectors, as well as the environment. Several ongoing multi-disciplinary studies hope to forecast the impacts of climate change on the water resources and future water availability within the South Saskatchewan River Basin. Finding ways to better manage water resources and reduce conflicts between users are some of the goals of the studies.

Spring snowmelt – B.Spirko

2.6 Ecosystems

Terrestrial Habitat

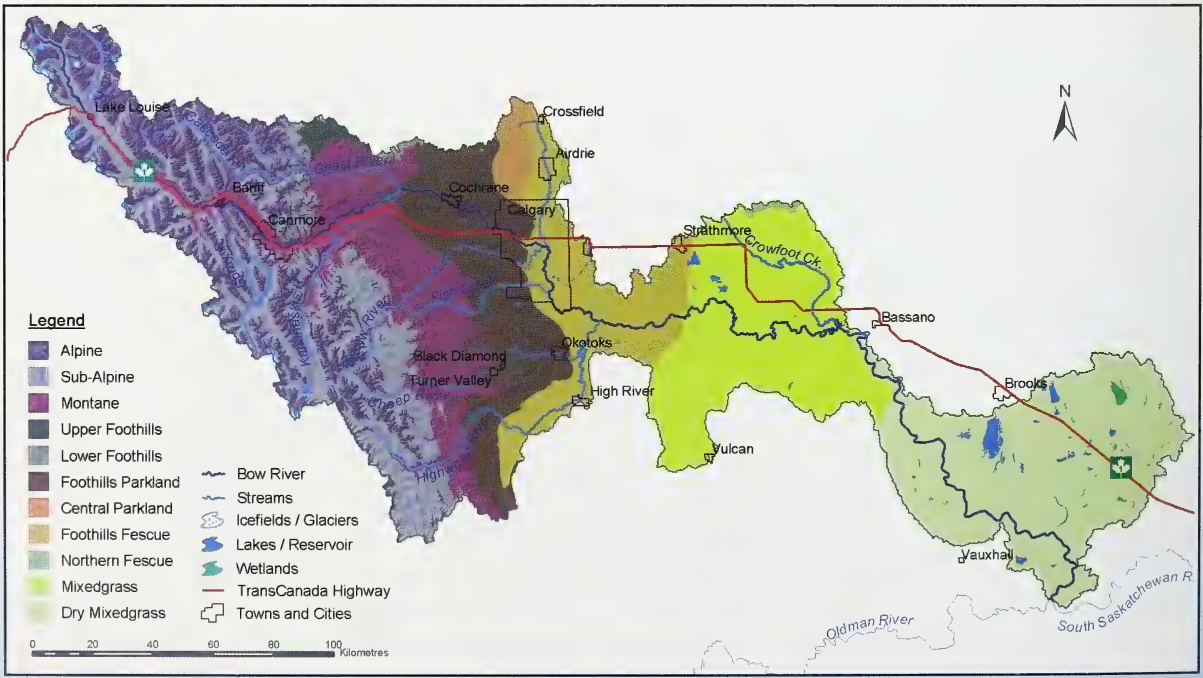
On the journey from the mountains to the confluence with the Oldman River, the Bow River encounters highly varied landscapes and ecosystems (Figure 2.4). From the west, the river flows through the mountains, along the foothills and onto the prairie. Through the mountains, the Bow Valley corridor includes steep, U-shaped valleys. Progressing from permanent ice cover and alpine tundra in the highest mountain elevations, there is a transition to sub-alpine fir and spruce forests on the lower mountain slopes. The montane area contains mixed deciduous and coniferous forests in the lower valleys and foothills west of Calgary. A transition from foothills parkland to foothills fescue occurs west of Calgary. Farther east, cottonwood and other species of poplar are the most common trees, but grasslands are the predominant vegetation. The mixed grass environment becomes dry mixed grass prairie east of Gleichen.[19]

The great diversity in terrain and plant communities within the basin provides habitat for a variety of large and small mammals. The river valleys are essential wildlife movement routes through the mountains, but human development and activities have compromised this function. The Trans-Canada Highway and Canadian Pacific Railway parallel the Bow River throughout much of the mountains and foothills and have disrupted ecosystem connectivity, altered habitats and negatively impacted many wildlife populations. Bighorn sheep, elk, moose, wolves, cougar and bears are some of the mammals commonly found within the upper mountainous portion of the watershed.[50]

On the prairies, common mammals include pronghorn antelope, deer, coyotes, jackrabbits, and ground squirrels. Numerous bird species, including birds of prey, waterfowl and songbirds, also use these habitats. Native habitats are more limited in the eastern part of the basin due to extensive agricultural development. While many species of wildlife can adapt to human influences and changing environments, others have disappeared or decreased in abundance since historical times (e.g. wild bison, burrowing owl).

Several species of animals and plants that can be found in the Bow River Basin are currently listed as "at risk" or "may be at risk" within Alberta. At risk mammals include the swift fox, and possibly the grizzly bear. Birds have the most species listed as at risk, due to the loss of wetlands and native grassland habitat throughout the basin. Another influence on the status of migratory birds includes habitat changes that may occur

Figure 2.4 Natural regions in the Bow River Basin[39 40]



outside the basin and across their migratory routes. The trumpeter swan, piping plover, greater sage grouse, burrowing owl, ferruginous hawk, and peregrine falcon are all considered at risk; the long-billed curlew and short-eared owl may be at risk. The prairie rattlesnake, Great Plains toad, Canadian toad, and plains spadefoot may also be at risk, while the northern leopard frog is at risk. Several species of native orchids and ferns may also be at risk.[44]

Riparian and Wetland Habitat

Riparian areas and wetlands are an integral component of the Bow River watershed. Riparian areas can be found along the stream banks and floodplain of the Bow River and its tributaries, as well as along the margins of still waters, such as wetlands and lakes. Wetlands are found primarily on the prairies, in the eastern portion of the Bow River Basin. They occupy a transitional zone between the land and purely aquatic ecosystems, and are not necessarily associated directly with a river.

Both wetlands and riparian areas are typically areas of high biological diversity and production. Abundant vegetation provides food and cover, while the varying water depths and flows provide habitat for a diverse assemblage of plants, mammals, and migratory birds.[208] Up to 80% of the breeding bird populations in the United States and Canada rely on wetland habitat, including more than 50% of the 800 species of protected migratory birds.[205]

Riparian areas and wetlands serve to buffer the river from disturbances on the land. These areas attenuate floods and protect downstream lands from flooding and erosion. Wetlands also remove sediments and nutrients prior to recharging groundwater levels. Riparian areas and wetlands can be effective sinks for nutrients and bacteria in agricultural landscapes,[118] reducing impacts on downstream water quality and aquatic systems. As a result, riparian areas and wetlands are key to protecting the flows and water quality of the Bow River watershed.

The diversity of plants in riparian and wetland areas is due in part to natural disturbances such as floods. Over the past century, the natural flood regime of the Bow River has been altered due to dam construction and water withdrawals, resulting in poor regeneration of cottonwoods and other trees in the lower reaches.[38 200] Invasive weeds, such as purple loosestrife and tansy, have also become established throughout the floodplain.[38] Channelization and armoured banks also result in a non-functional floodplain and have altered riparian habitats.[123] Of the sections of the Bow River assessed by the Alberta Riparian Habitat Program - Cows and Fish, 72% were considered unhealthy, or healthy but with problems. Basin-wide concerns include the presence of weed species, reduced vegetation, the operation of dams, and flood control.[38]

Changes to wetlands have occurred throughout the Bow River Basin. Wetlands have been drained, tilled or filled to allow rural and urban development and to enhance agricultural production.

The discharge of pharmaceutical drugs

Small amounts of prescription and non-prescription drugs (e.g. nicotine, antibiotics, antidepressants) are turning up in treated wastewaters, which are then discharged into receiving streams. The wastes of livestock treated with veterinary pharmaceuticals can also contribute trace amounts to surface waters. Surface waters most susceptible to contamination are those downstream from large urban areas or intensive livestock operations. The occurrence of these chemicals in surface waters has become more evident in the last decade because of continual improvements in water analyses that can now detect a wide array of these chemicals.[95]

Many of these chemicals are not covered by water quality guidelines and little is known about their effects on the environment. A small sub-set of these pharmaceutical drugs is known as endocrine disruptors. These synthetic hormones and steroids have the potential to affect the reproductive health of aquatic organisms. Overall, the impacts of these pharmaceutical wastes on human health and aquatic organisms require further study. A report on the presence of these drugs in the Bow River is being finalized.[95 151]

The status of Alberta wildlife

Throughout this report, the status of species within the Bow River Basin is described using Alberta's status evaluation system. The Fish and Wildlife Service of Alberta Sustainable Resource Development provides an initial assessment of the status of a species, which is evaluated using all relevant current data for vertebrate, invertebrate, plant and fungi species in Alberta. Several criteria were used to rank each species, including population size, number of occurrences, distribution, threats to habitat and population, and trends in distribution and population. Because the process is identical to that used by other provinces and territories in Canada, comparisons across the country can be made.

An evaluated species may be put into one of nine status categories:

At Risk: Any species known to be "At Risk" after formal detailed status assessment and designation as "Endangered" or "Threatened" in Alberta.

May be At Risk: Any species that "May Be At Risk" of extinction or extirpation, and is therefore a candidate for detailed risk assessment.

Sensitive: Any species that is not at risk of extinction or extirpation but may require special attention or protection to prevent it from becoming at risk.

Secure: A species that is not "At Risk", "May Be At Risk" or "Sensitive".

Undetermined: Any species for which insufficient information is available to reliably evaluate its general status.

Not Assessed: Any species that has not been examined.

Exotic/Alien: Any species that has been introduced as a result of human activities.

Extirpated/Extinct: Any species no longer thought to be present in Alberta ("Extirpated") or no longer believed to be present anywhere in the world ("Extinct").

Accidental/Vagrant: Any species occurring infrequently and unpredictably in Alberta, i.e., outside its usual range. These species may be in Alberta due to unusual weather occurrences, an accident during migration, or unusual breeding behaviour by a small number of individuals. If a species appears in Alberta with increasing predictability, it may eventually be given a different rank. Changes in "Accidental/Vagrant" species may be a good indicator of general ecosystem or climatic changes.

Alberta's status document is updated every five years; the most recent was completed in 2000. Refining the status rankings for each species is an ongoing task and filling the data gaps requires a concerted effort by government agencies, non-government groups and committed individuals. Wild species populations can change relatively rapidly, particularly in areas affected by human use. There is a continuing need to monitor these changes to ensure populations remain viable and to anticipate the effects of changing habitat conditions.

In many instances, those wetlands that do remain have been modified by urban impacts and agricultural practices which result in increased sedimentation, agricultural chemical inputs, nutrient enrichment, modified water levels and flows, and altered plant and animal communities. While data are unavailable for the Bow River Basin, it is estimated that 64% of wetlands have been lost within the settled portion of Alberta and that the City of Calgary has lost up to 90% of its wetlands. Calgary recently developed a Wetland Conservation Plan, which provides for the future protection of wetlands within this urban environment.[76]

Since the early 1940s, Ducks Unlimited Canada has been working with the irrigation districts and today there are many managed wetlands that provide critical habitat. Conservation efforts protect and restore habitat for wildlife breeding and migration activities and some previously drained agricultural lands have been converted back to wetland use or provide permanent native vegetation. Irrigation reservoirs provide important staging and moulting areas, while the canals and drainage systems provide additional riparian and channel habitat within the basin. Regardless, present conservation efforts to preserve and restore wetlands and associated habitat within the basin cannot fully offset these impacts nor keep pace with the rate at which they are occurring.[242]

The linear habitat provided by the irrigation canals also serves as wildlife movement corridors and is easily searched by predators. As a result, waterfowl nesting may be abundant in these canals, but their success is poor. Since declines throughout the 1960s through the 1990s, restoration efforts now appear to be having a positive influence on several duck, swan and goose populations.[174] Data collected between 1963 and 2002 indicate that total duck numbers across the southern Canadian prairies are recovering, however, the northern pintail and lesser scaup continue to experience declining populations.[173 202]

Loss or degradation of wetland or riparian habitat not only adversely affects the plants and animals in these ecosystems, but also affects biodiversity in the surrounding upland habitats[70] and the water quantity and quality of aquatic systems.

Aquatic Habitat

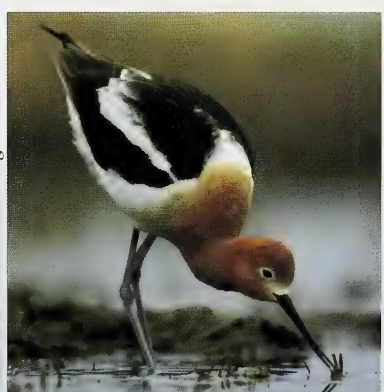
The Bow River and its tributaries provide habitat for aquatic mammals (e.g. beaver, muskrat), aquatic plants, benthic invertebrates, and fish (Table 2.3). More than half the length of the Bow River, from its headwaters to the Carseland Weir, is cold-water aquatic habitat,[90] suitable for fish species like rainbow and bull trout that require cold, clean, fast moving water. From the BNP boundary to the Bearspaw Dam, fish habitat is limited by the large daily fluctuations in flow that result from the hydroelectric facilities. The Bearspaw Dam re-regulates the river, providing more stable flows downstream. Wastewaters and nutrients discharged to the river from the various municipalities stimulate biological production. These factors have resulted in consideration of the stretch of the Bow River downstream of Calgary as a “blue ribbon” fishery, particularly for rainbow and brown trout.[133]

Several of the dams present barriers to fish movement, negatively impacting both native and introduced species.[90] Habitat loss and modification, over-fishing and non-native fish introductions are other pressures facing native fish populations. While most fish species are listed as secure, the spoonhead sculpin may be at risk and the bull trout, lake trout and sauger are listed as sensitive in Alberta.[44]

Between the Carseland Weir and the Bassano Dam, the Bow River gradually changes to cool-water aquatic habitat, suitable for sturgeon, pike and walleye. These species can tolerate the warmer, slower and more turbid water found in the lower reaches of the Bow River. Diversions for irrigation greatly reduce the flows of the

Mallard Reflections – A.Mackeigan

American Avocet – A.Mackeigan



Great Blue Heron – A.Mackeigan

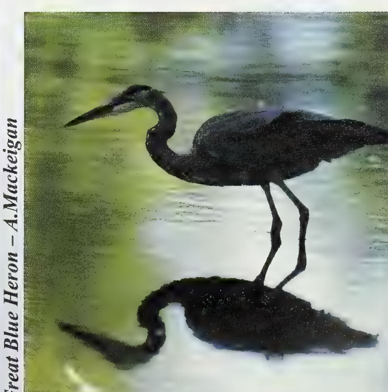


Table 2.3 Fish in the Bow River system[90 165]

Fish Species	
Trout and Whitefish	**Minnows**
Cutthroat trout	Longnose dace
Rainbow trout[a]	Lake chub
Brown trout[a]	Flathead chub
Brook trout[a]	Emerald shiner
Bull trout	Spottail shiner
Dolly Varden[a]	River shiner
Lake trout	Flathead minnow
Mountain whitefish	Pearl dace
Lake whitefish[a]	**Perches**
Mooneyes	Walleye
Goldeye	Sauger
Mooneye	Yellow perch
Suckers	**Other Groups of Fish**
White sucker	Lake sturgeon
Longnose sucker	Northern pike
Mountain sucker	Burbot
Quillback	Trout-perch
Shorthead redhorse	Brook stickleback
Silver redhorse	Spoonhead sculpin

[a] Introduced species

river downstream of the Bassano Dam, restricting fish habitat. With lower flows, the temperature of the water is able to rise more quickly during the summer, and temperatures often exceed the tolerance of some of the cool-water fish species.

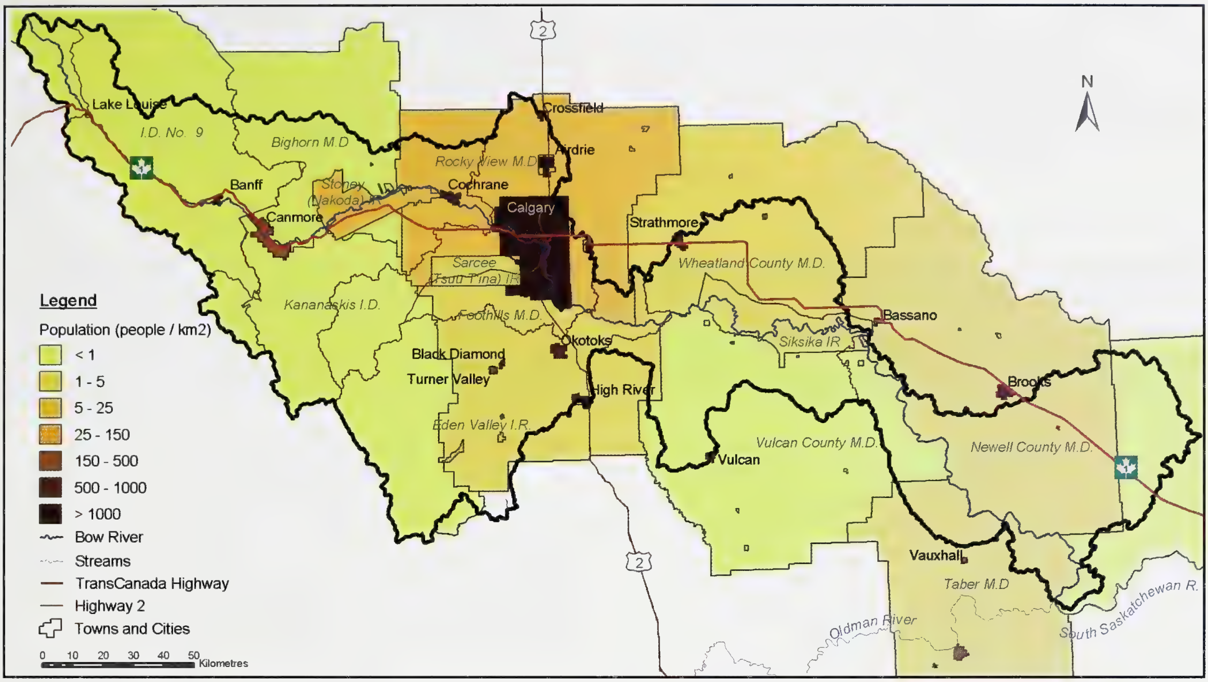
During times of low flows, the warm, shallow, nutrient-rich waters can occasionally experience low dissolved oxygen concentrations and pH fluctuations. Although water quality has improved greatly since the fish kills seen throughout the 1960s to 1980s, the periodic occurrence of these conditions can still stress the fish in the river.[90]

The fish species and their distribution in the basin have changed during the last century, particularly upstream of Calgary and in the tributaries. While mountain whitefish generally remain the most common species throughout the Bow River system, populations of the native cutthroat and bull trout have been substantially reduced. These two species once ranged from the extreme headwaters feeding Bow Lake to the mainstem downstream of Calgary. Currently, these species can be found throughout several basin tributaries, but in the mainstem, are only present within the mountainous headwaters of BNP.[163 165] Introduced rainbow, brown and brook trout have largely replaced these native species.[64] While stocking of some species, (brook trout in 1911) was done purposefully, to improve angling, other introductions were accidental.[207 208]

Information on fish habitat in the Bow River is too detailed to include in this report; however, several key areas within the basin are noteworthy. The section of the Bow River from Banff to Calgary provides important spawning habitat for mountain whitefish and brown trout. Brown trout also spawn within the City of Calgary and in the lower Elbow River. Mountain whitefish overwinter in the Bow and lower Highwood rivers, and make their way to the upper Sheep and Highwood rivers to spawn.[90] Rainbow trout spawn in the Bow River near Bearspaw, the Sheep and Highwood rivers and in smaller tributaries.

Westslope Cutthroat Trout – R.Blanchard

Figure 2.5 Human population density along the Bow River[163]



2.7 Population

As of 2003, more than 1.12 million people resided within the Bow River watershed (Figure 2.5).[224] With more than 900,000 people, Calgary is the largest urban centre and represents over 80% of the basin's total population. While some of the population is truly rural, most people here live in the more than 40 communities, ranging from small towns like Vauxhall to midsize towns like Canmore.

Several of the centres with populations over 10,000 are bedroom and/or country residential communities adjacent to Calgary. Many of these communities are found along the Bow River, illustrating the importance of the river to the establishment and continued existence of both urban and rural development.

First Nations people have used the Bow River for 10,000 years.[50] The Bow Valley was a natural strategic base and transportation route for people of the Blackfoot Nation. The Blackfoot people made bows from the trees along the river's banks. This use of the Bow River led to one of its names being "river where the bow reeds grow."[131]

Today's human use of the river includes residential and recreational use as well as water withdrawals and discharges for domestic, industrial and agricultural purposes. As a result, human impacts on the river are extensive and impact its natural flow regime, water quality, fish populations, and aquatic plant communities.

The population within the basin is forecast to grow by about 50% – to 1.65 million by 2030.[137] The majority of this increase is projected to take place in Calgary and its immediate vicinity. This growth will undoubtedly place further stresses on the Bow River. Impacts such as stormwater runoff and additional demands for instream flows for assimilation of wastewater effluent will likely become greater challenges for urban areas and downstream users.

With appropriate management, however, these impacts may be ameliorated. Some of the ways grassroots organizations, industries and governments plan to effectively manage these future uses, and protect the Bow River, are described in Chapter 11.

2.8 Water Use

In addition to providing ecosystem requirements for aquatic plants and animals, the Bow River is used for:

- Hydroelectric generation
- Water licensing and allocations
- Effluent dilution
- Recreation

Hydroelectric Generation

TransAlta Utilities (TAU) operates hydroelectric power generation stations at 11 locations in the Bow River Basin (Table 2.4). These facilities generate approximately 838,000 Megawatt hours (MWh) of electricity each year.[104] While only providing about 3% of TAU's annual electrical production, these power sources are essential for a rapid response to peak electrical demands. They also provide load control, which is the minute-to-minute variation in electricity demand within the system.[115] However, these hydroelectric developments and diversions have resulted in substantial changes to the natural flow regime of the Bow River and its Cascade, Spray, Kananaskis, and Ghost river tributaries.

The hydroelectric facilities include six dams, the construction of which has created six large reservoirs within the Bow River Basin. These reservoirs store and release water, resulting in seasonal changes to the downstream flows of the Bow River and in the water levels of the upstream storage reservoirs. The reservoirs hold back much of the spring snowmelt in order to store it for gradual release throughout the rest of the year, generating a reliable supply of electricity. Generally, the reservoirs are filled during the spring and summer and are depleted during the winter months. The total storage of these reservoirs is approximately 25% of the average annual runoff of the Bow River at Calgary.[33]

Downstream, this operating cycle reduces the spring runoff peak of the river and supplements the low flows during the fall and winter. When compared to historic data, flows in the Bow River are lower from May through July or August and are higher the rest of the year. The upstream impacts of this cycle include the formation of a reservoir with much higher water levels than the original channel, though the winter release of water from the reservoirs causes levels to be drawn down, often by several metres. During wetter than average years, the dams alter the natural flow regime of the Bow River relatively little, but they have a greater effect during years that are drier than normal.[90]

Other hydroelectric facilities are considered run-of-river developments and do not have reservoirs. These facilities have relatively small impacts on the seasonal flows of the Bow River. Water is passed through the generation plants as soon as it arrives from upstream.

In addition to seasonal flow changes, some of the hydroelectric facilities cause large daily fluctuations. Electricity production and release of water downstream are timed to meet peak demands for power in the morning and evening. The accompanying rapid and variable water release is termed hydro-peaking. The Bearspaw Dam is used to re-regulate the fluctuating daily water releases from the Ghost Dam, resulting in relatively constant flows downstream.[104]

These hydroelectric facilities influence not only the timing and magnitude of streamflows along the Bow River, but also the river's water quality and ecosystem characteristics. Reductions in spring and summer flows limit the flooding necessary for the regeneration of riparian vegetation, including cottonwood trees.[200] Lower spring flows negatively affect fish habitat, but the higher fall and winter flows likely benefit habitat. Fluctuating water levels destroy most of the productive littoral zone of the reservoirs and increase erosion and sedimentation of the water. The reduction in plant and animal life along the margins of the reservoirs reduces the habitat and food available to fish.[115] Hydro-peaking can create problems with ice cover stability and elevate the possibility of winter ice jam flooding. Recreational users of the river can be placed in some danger if water levels and flows fluctuate over a short period of time.

Ghost Dam – BRBC

The operations of these facilities do take into consideration the various needs of other users of the river. Licensing agreements for some of the hydroelectric facilities require TAU to maintain certain maximum reservoir levels, or minimum downstream flows. During the summer, releases from the reservoirs allow sufficient water levels for recreational use. Stored water is released during the winter to maintain downstream water quality and fish and riparian habitat.[167] Higher winter flows provide additional dilution of municipal and industrial effluents.[115] While these operating conditions help to ensure that sufficient water is provided to downstream licensees and to maintain aquatic resources, they cannot entirely offset the negative impacts of hydroelectric production on the Bow River.

Table 2.4 Hydroelectric facilities in the Bow River Basin[17 104]

Plant Name	Location and Source Water	Built	Purpose	Annual Electrical Production (Mwh)	Reservoir Storage (million m^3)	Reservoir Area (ha)[a]
Cascade	Reach 2/3: Cascade River/North Ghost River/Lake Minnewanka	1942	Peak demand power	52,612	221.9 (Lake Minnewanka)	2,227 (originally 1,401)
Spray System (Three Sisters, Rundle and Spray)	Reach 2/3: Spray Lakes near Canmore	1951	Load control and peak demand power	287,800	180.3 (Spray Lakes)	1,779 (originally 180)
Kananaskis Falls	Reach 3: Bow River near Seebe	1913	Continual power production	93,034	None	None
Horseshoe Falls	Reach 3: Bow River near Seebe	1911	Continual power production	83,200	None	None
Interlakes	Reach 3: Upper Kananaskis River	1932 1955	Peak demand power	8,585	124.5 (Upper Kananaskis Lake)	865 (originally 580)
Pocaterra	Reach 3: Upper Kananaskis River	1955	Peak demand power	29,549	63.0 (Lower Kananaskis Lake)	641 (originally 290)
Barrier	Reach 3: Lower Kananaskis River	1947	Peak demand power	40,351	24.8 (Barrier Lake)	304
Ghost	Reach 3: Bow River downstream of Ghost River	1929	Peak demand and continual power production	172,033	92.6 (Ghost Lake)	1,146
Bearspaw	Reach 3: Bow River near Calgary	1954	Re-regulation of flows and continual power production	70,691	None	248
Total				**837,855**	**707.1**	**7,210**

[a] Original size (in hectares) of the lake prior to dam construction is included in the brackets

Water Licensing and Allocations

Approximately 46% of the average annual natural flows of the Bow River are withdrawn (either consumed or diverted) prior to the confluence with the Oldman River.[33] Many of these licences are currently underused. As the existing licence holders increase their use, the amount of water withdrawn will increase. The federal government issues licences for the diversion and/or use of surface waters in the Bow River Basin within Banff National Park. Water use in the rest of the basin is regulated by the Government of Alberta, which issues licences for irrigation, non-irrigation agriculture, municipal and industrial uses of the Bow River and its tributaries (Table 2.5).[25 33]

Irrigation licences include the basin's three major Irrigation Districts and their members, as well as many smaller irrigators. Some agricultural producers in the reach use irrigation water for livestock watering, fish farms and tree farms, while others don't use irrigation water at all. Municipal licences are those held by cities, towns and villages, as well as schools, recreation centres, fire protection systems, residential sub-divisions, and water co-operatives. Industrial licence holders include companies involved in oilfield injection, oil and gas plants, food processing, and aggregate washing.

The "other" category in Table 2.5 includes smaller licences for golf courses, parks, water management, waterfowl projects, household, and storage purposes. Domestic wells are unlicensed and not included in the municipal contributions. Rural households have the right to withdraw up to 1,250 m^3 annually for domestic purposes without a licence.[25 36]

At the lowest reach of the river, 68% of the average flows are allocated for withdrawal. In high flow years, this percentage is lower (around 25%), but in low flow years, the percentage increases to around 80%. At times the total licensed allocation exceeds the natural flows of the Bow River. In general, peak demands for most users occur during the late summer months when the river flows are typically low and may not permit a full use of the licensed amount. Currently, the instream objective is the governing factor for assessing when allocations are stressing the river system (see Section 2.10). When these flows are approached, Alberta Environment curtails withdrawals.[25]

Table 2.5 Water licences in the Bow River Basin[25]

Water User	Annual Licensed Allocation (m^3)	Percentage of Total Allocation (%)
Irrigation	2,114,963,935	76.35
Agriculture	10,243,381	0.37
Municipal	486,694,923	17.57
Industrial	78,947,406	2.85
Other	79,161,35	2.86
Total	**2,770,011,380**	**100.00**

If the water supply cannot satisfy the requirements of all licensees, water is managed according to the principle of priority in time, or "first in time, first in right." The earliest licensee is entitled to receive the entire quantity of water in their licence before the next licensee can receive any water at all, and so on. Water transfers are an alternative to enforcing this priority system in times of drought or insufficient flows. Senior water licences can be transferred to junior users, in a co-operative effort to provide water to those who need it most at the times they need it most. By holding back up to 10% of all transfers, additional flows may be returned to the river.[25]

Part of the problem of allocation and insufficient flows occurs because many of these licences were issued decades ago, when capacity and limitations were not the concern they are today. Current licensees are now required to ensure that the diversion of water will not decrease the flows of the Bow River beyond certain limits. The concept of maintaining flows for aquatic resources, including fish, is being expanded and strengthened. Some recent licences are subject to instream objectives being met before withdrawals from the Bow River are permitted (Section 2.10).

In addition to these surface water licences, approximately 500 licences to withdraw groundwater within the Bow River Basin are issued by the Government of Alberta.[33] These groundwater licences are issued for agricultural, municipal and industrial purposes. Because they comprise a relatively small portion of the total water licences in the Bow River Basin (98% of consumption is from surface water sources compared to 2% from groundwater), they are generally not discussed in this report.

Irrigation and Agriculture

Irrigation is by far the largest user of water in the Bow River Basin. These withdrawals support critical economic development, domestic water supplies and recreational opportunities within the basin. Irrigated agriculture has been an important part of the Bow River Basin since the late 1800s.[12] Irrigation water also makes possible a large livestock industry and remains a major

source of domestic water supply for rural people within the basin. Irrigation reservoirs (Table 2.6) and canals are important recreational facilities for residents of the basin and tourists, and also provide fish and wildlife habitat. In recent years, a variety of initiatives and improvements have made more efficient use of this diverted water. Food processing wastewaters are being treated and used to irrigate crops and farmers are becoming more conscious of environmental concerns, through programs such as Alberta Environmentally Sustainable Agriculture (AESA) and the Alberta Environmental Farm Plan.

Though limited in precipitation, the Bow River Basin is highly suitable for the development of irrigated agriculture, with a greater number of frost-free days than most parts of the province, good soils for growing a variety of crops and little potential for water erosion in most parts of the basin.[8] Relatively high levels of solar radiation mean that Reaches 5, 6, 7, and 8 are suitable for growing many specialty crops, as well as forages and grains.

Irrigation of agricultural crops is the major consumptive water use in the Bow River Basin. Though 233 private licences draw water from the river system, about 98% of the diversions are for the irrigation districts. Three legislated irrigation districts, the Western (WID), Eastern (EID) and Bow River Irrigation District (BRID) (Figure 2.6) are licensed to draw a total of almost 1,700 million m^3 of water from the Bow (Table 2.7).

Though licences for water allocations remain fixed, the actual volume of water used by the irrigation districts varies considerably from year to year. For example, in 1997, the total volume of water actually diverted by all 13 irrigation districts was about 68% of the licensed volume. In the extremely hot summer of 1988, the irrigation districts diverted about 84% of their licensed allocation. In 1993, a wet summer, only 40% of the allocation was actually diverted.[5]

The irrigation districts also make water available for non-crop uses. In drought years, such as 2002 and 2003, the irrigation districts may apportion and restrict water

Figure 2.6 Irrigation Districts in the Bow River Basin[7,39]

Table 2.6 Irrigation reservoirs in the Bow River Basin

Irrigation District	Reservoir	Storage (m^3)	Area (ha[a])
WID	Chestermere Lake	51,800	260
WID	Langdon (Dalemead) Reservoir	78,950	245
Total WID		**130,750**	
Carseland-Bow River System[b]	Little Bow Reservoir	210,780	530
Carseland-Bow River System[b]	Travers Reservoir	1,046,380	2,265
Carseland-Bow River System[b]	McGregor Lake	3,510,590	5,100
BRID	Badger Resevoir	536,500	890
BRID	H Reservoir	22,200	130
BRID	Lost Lake	50,500	485
BRID	Scope Reservoir (Hays)	197,400	575
Total BRID		**5,274,350**	
EID	Cowoki Lake	197,350	730
EID	Crawling Valley Reservoir	1,305,000	2,515
EID	J Reservoir	6,150	115
EID	Kitsim Reservoir	265,200	690
EID	Lake Newell	3,202,150	6,495
EID	One Tree Reservoir	23,450	90
EID	Rock Lake	92,500	225
EID	Rolling Hills Reservoir	460,000	585
EID	Snake Lake	182,300	105
EID	Tilley A (Campbell) Reservoir	333,000	620
EID	Tilley B Reservoir	382,350	1,410
EID	Bantry 1 & 2 Reservoir	Minimal	
EID	Little Dam Reservoir	Minimal	
EID	Bassano Reservoir[c]	Minimal	
Total EID		**6,164,600**	
Total Irrigation Districts		**11,700,450**	

[a] Full supply-level surface area

[b] Operated by Alberta Environment, water diverted from the Bow River to these reservoirs in the Oldman River Basin is used by the BRID

[c] On-stream reservoir (directly on the Bow River) that operates as a diversion weir. All other reservoirs are off-stream

Table 2.7 Irrigation Districts in the Bow River Basin[12 188]

Irrigation District	Year Established	Year and Source of First Water Drawn for Irrigation	2002 Water Allocation (m^3)	2002 Return Flows (m^3)	Irrigated Hectares
WID	1944	1907 – from CPR works	197,850,486	48,234,073	166,891
BRID	1968	1920 – from Canada Land & Irrigation Co. works	555,066,900	78,449,445	501,549
EID	1935	1914 – from CPR works	939,913,280	119,647,738	693,422

use by farmers and ranchers, giving priority to municipalities and domestic water users. Water use by all licence holders may also be limited to meet flow apportionment agreements with Saskatchewan.

Some water will always be lost to evaporation, seepage, certain management practices, and return flows, however,the irrigation districts and their members have worked to improve the efficiency of the system, both at the distribution level and on the farm. Irrigation efficiency is the ratio between the total amount of water diverted to irrigation and the amount that is actually available for crop use. The principal causes of water loss are due to on-farm application inefficiencies, canal seepage and evaporation. In the late 1970s and early 1980s, seepage losses were a substantial factor, with about 18% of irrigated lands in the Bow River Basin affected by salinity and water logging. Since then, many canals have been lined with plastic and pipelines have been installed to reduce seepage and evaporation.

Increasing irrigation efficiencies

Return flow is the surplus water returned to a river system through natural drainage or irrigation diversions. In irrigation, it is an inevitable result of attempting to match supply and demand in the canal distribution system. Recent studies show irrigation return flow to be largely a factor of infrastructure characteristics, on-farm irrigation methods and district management. Irrigation farmers and districts are concerned about reducing return flows in order to make more efficient use of water, decrease canal maintenance costs, improve water quality in the river basin, and improve public perception of their management practices. To this end, the Irrigation Branch and the districts have increased their efforts at quantifying return flows and identifying ways to minimize them.

Operational spills, on-farm drainage and base flows are the major components of irrigation return flow. Spills are usually the result of sudden decreases in demand (e.g. heavy rains or equipment breakdowns) or the need to flush canals at the start of the irrigation season. Base flow is the amount of water designed to be left in the irrigation delivery system to accommodate sudden increases in demand, for example, to offset seepage and evaporation losses or to ensure farmers at the end of the delivery system have sufficient water for their requirements. Base flows are set by the irrigation districts to balance supplying these needs and having as little return flow water as possible.

While the trend toward increased efficiencies and reduced return flows is positive in terms of water use and conservation, another consequence is an effective loss of aquatic habitat. An unintentional benefit of the excess water that runs off irrigated lands into the canal system is that wetland, riparian and aquatic habitat is created for waterfowl, fish and other animals and plants. With increased efficiencies, the water flow to these habitats that have been around for decades is decreased. One potential solution is to continue to feed the canals with designed leakage that maintains a certain amount of this created habitat.

WID Drain – AAFRD

This rehabilitation of the canals is 57% completed in the BRID and seepage losses are now estimated to be only 2.2%. In the EID, rehabilitation is about 32% completed and seepage losses are estimated at 2.6%. The WID has a longer conveyance system compared to the area being irrigated, and only 18 to 20% of its 1,200 km of canal has been rehabilitated. Seepage losses have been reduced to 6.8% of its licensed volume.[188]

Most farmers have switched to low pressure, drop tube, center pivot sprinklers that are far more efficient than the surface (flood) irrigation or wheel-move systems used in the past. Studies of irrigation delivery systems show return flows from surface irrigation are typically 75 to 100% greater than with sprinklers. On-farm efficiencies have gone from less than 35% in 1965, to 54% in 1980, to more than 70% in 2000.

A new Alberta Water Act, passed in 1999, allows water licence holders to transfer all or a part of a licence, in hopes of making the most efficient use of scarce water resources. For example, a farmer can move part of a licence from an assessed portion of land, to one that isn't assessed for irrigation, if the transfer would make the water use more efficient through better crop rotations or by applying water to a higher value crop. It is hoped that through these transfers current or historical water allocations may be distributed more effectively to a broader spectrum of users, allowing water-based economic development to continue.

Soil Salinity

Soil salinity and associated drainage problems are two of the challenges to the sustainability of agriculture on irrigated land. Saline soils reduce productivity of farm crops and can lead to increased salinity of ground and surface waters. A study done in the late 1980s showed that saline soils and water logging affected about 57,500 ha in the Bow Basin.

Soils are naturally saline in many areas of Alberta due to leaching of trace minerals from the parent rocks. Irrigation increases salinization by upsetting the balance between the addition of water and evapo-transpiration. As water is applied to the land, either through precipitation or irrigation, it moves through the soil, dissolving the naturally occurring salts. The salt-laden waters move down-slope to low lying areas of land. As the water evaporates or is used by plants, the salts are left behind to accumulate and the area becomes more saline. Groundwater is directly affected when salt-laden water percolates through the soil to the water table. Surface waters can be affected by salt loading – the addition of soluble salts to rivers and lakes through runoff or irrigation return flows.

The return of marginal farmland to pasture and wetlands has also helped decrease salinization and improve wildlife habitat. Rehabilitation of the irrigation canals to reduce seepage, a decrease in over-irrigation, and improved on-farm drainage has reduced salinization and water logging of soils and the subsequent salinity of water sources. However, it is also important to note that improved efficiencies in drainage may decrease wetland habitat.

Saline soils – AAFRD

Alberta Agriculture, Food and Rural Development's Irrigation Branch estimated that a 10 to 20% expansion of farm water use would be sustainable in the Bow Basin, based on the increase in irrigation efficiencies since the 1960s.

Though Calgary's sewage treatment plants are the largest single source of nutrients, bacteria and salts in the Bow River Basin, agriculture does contribute contaminants to surface water bodies and, to a much lesser extent, to groundwater. Manufactured fertilizers, manure and pesticides are the principle agricultural contaminants of water quality in the river and its tributaries. These contaminants commonly enter the water as runoff following spring snowmelt and heavy rains. Return flow channels can also carry contaminants to the Bow, especially from areas where intensive agriculture is practiced, such as Crowfoot Creek.[139]

Unused irrigation water re-enters the river or main canals as return flows. In a study based on more than 1,000 return flow water samples from Alberta's irrigation canals, phosphorus levels were found to exceed the provincial guidelines for aquatic life 61% of the time. Herbicide levels in return flows have often been found to exceed water quality guidelines for irrigation and can negatively impact crop yields on downstream fields. Concentrations of salts, phosphorus and pathogens also increased in return flows, compared to water samples taken from source intakes.[65]

The growth of large feedlots in the Bow Basin is a challenge for both water quality and quantity. Intensive livestock operations (ILOs) require large amounts of water for cleaning and for watering the animals. For example, Alberta Environment requires a 5,000 steer ILO to reliably supply 99,000 m^3 a year of water.[5]

In the last decade, farm producers, the agricultural industry and government have made great strides in reducing pollution problems and in meeting agriculturally related environmental challenges in general. Livestock producers have put up fences to keep cattle out of streams and have built diversions to prevent livestock wastes from entering waterways. Farmers have returned previously cultivated marginal lands to pasture and wetland use. Many have adopted zero or minimum-till practices to conserve moisture and reduce sediment runoff into the river and its tributaries.

Government and industry have also undertaken research on crop varieties and management practices to improve crop yields with less water and less environmental impact. The industry is becoming increasingly pro-active in fostering and initiating sustainable agricultural practices that will reduce impacts on the Bow River Basin.

Municipalities

Municipalities in the Bow River Basin are heavily dependent on the Bow River and its tributaries for water supply, effluent assimilation, recreation, and urban parks. The City of Calgary is by far the largest municipal user of water in the Bow River Basin. It stores water from both the Bow and Elbow rivers in the Bearspaw and Glenmore reservoirs, respectively. Calgary also services the communities of Airdrie and Chestermere. Upstream of Calgary, the majority of the communities use groundwater as their domestic supply source. Exceptions include Canmore, which uses water from the Spray Lakes Reservoir, and Cochrane, which draws water from the Bow River. Downstream of Calgary, water is supplied from surface waters, groundwater and irrigation works.[56]

It is expected municipal water consumption per capita in the basin will decrease moderately in the next decade, as conservation measures are implemented. Beyond that, per capita consumption will decline at a slower rate.[137]

Conservation measures that are increasingly becoming part of municipal policy include:

- Increased water and sewer charges, increasing charges during times of greatest demand and charging all users.
- Restrictions on specific water uses at times of greatest demand and/or lowest supply (e.g. watering of residential lawns or acreages).
- Promotion of water saving devices in new construction and retrofits of existing buildings (e.g. low flow toilets and shower heads).
- Educational campaigns on environmental protection and sustainable development.
- Use of drought-resistant plants (xeriscaping).
- Reducing distribution system losses through leak detections and upgrading old infrastructure.
- Metering and invoicing users for actual water consumption.

Overall, municipal return flows in the Bow River Basin have been estimated at 94% of consumption.[56] Urban areas typically return almost all their water consumption back to the river through wastewater effluents.[33] There are two types of wastewater conveyance systems: sanitary sewer lines carry sewage from homes and businesses for treatment at a wastewater treatment plants, prior to discharge to the receiving river; storm sewer lines carry runoff from streets, roofs and parks either directly to the river or to some kind of treatment facility.

Stormwater can be treated with the sewage at a WWTP (combined system), or discharged directly, with or without some form of treatment, to the receiving river (separate system). Most of the larger municipalities in the Bow River Basin have separate systems. The City of Calgary uses screens, wet ponds and wetlands to improve their stormwater quality. Recently, Calgary completed a study of urban stormwater pollution in preparation for establishing loading limits to surface waters.

However, 90% of urban lands in the basin receive little or no stormwater treatment.[56] Smaller towns and rural areas have combined systems, or no formal system at all, relying solely on overland drainage. The majority of larger communities downstream of Calgary use wastewater stabilization ponds or lagoons[56] that do not discharge directly into a river.

Municipalities can enhance river flows through inputs from these storm sewer systems, which rapidly transport rain and snowmelt from extensive paved areas to the river. Consequently, urban areas may contribute more water to the river than they withdraw. For example, the winter flows through Calgary are more than twice as high as natural levels, due to TAU operations as well as return flows from the city.[33] These combined flows enhance the downstream water supply and dilution of effluent discharges, but the return flows also add pollutants to the river.

How do they get it clean?

There are various types of wastewater treatment, depending on the components of the wastewater. Primary treatment consists of the physical removal of suspended solids, organic material and bacteria through screening, settling and skimming. Secondary treatment aerates the wastewater, utilizing bacteria and other micro-organisms to decompose organic material and remove suspended solids, bacteria and nutrients such as phosphorus and nitrogen. Tertiary treatment, using chemicals like alum, further reduces the bacterial, sediment, organic material, nutrient, or metals concentrations in the wastewater.

An alternative to more traditional WWTPs is the use of constructed wetlands, using natural processes. The natural filtering function of wetlands is used as a template for a man-made ecosystem of micro-organisms, aquatic plants and insects that break down organic material, settle sediments and remove nutrients, metals and other contaminants. Constructed wetlands have low energy costs and provide habitat for waterfowl. The technology is particularly suited for small rural communities, stormwater treatment, agricultural runoff and some industrial and food processing wastewaters. Many constructed wetlands are currently being used to treat wastewater and stormwater across Canada.[illegible] The Elbow Valley Constructed Wetland is a pilot project investigating stormwater treatment in the City of Calgary.

Operational challenges of constructed wetlands include poor phosphorus removal, environmental impacts (insect infestations, natural flooding) and limited life expectancy.[illegible] Managing the "retired" constructed wetland after 20 years or so of treating wastewaters is another concern. A wide range of organic pollutants and toxic metals may accumulate in the sediments of the constructed wetland, creating a hazardous waste disposal site that requires treatment itself.[illegible]

Nose Creek constructed wetland – F. Westcott

Municipal wastewaters contain a wide array of chemical and biological contaminants, depending on their source. Urban stormwater runoff contains road salts, metals, hydrocarbons, bacteria, and numerous contaminants associated with households and urban park management, including fertilizers and pesticides.[56] Effluent from WWTPs is higher in temperature, organic material, sediment, nutrients, and bacteria than the receiving environment, even after treatment. WWTP effluent also has lower dissolved oxygen concentrations and higher oxygen demands.[20 73 208]

Since the previous State of the Bow River Report,[57] substantial improvements in WWTP technology and system upgrades have occurred. Lake Louise, Banff, Canmore, and Calgary all use tertiary treatment and have greatly improved the quality of treated wastewater discharged to the Bow River. Cochrane, Airdrie and Chestermere currently pipe their wastewater for treatment in Calgary. Other communities use lagoons or septic tanks to treat wastewater.[56 117]

The City of Calgary's two WWTPs are the largest municipal dischargers in the Bow River Basin. However, they now contain state-of-the-art technology. A recent review of Canada's WWTPs gave Calgary the only A+ rating (up from the only A in 1999).[212]

The Bonnybrook Plant has an average design capacity of 500,000 m^3 per day and uses the most recent technology in biological nutrient removal, generally avoiding the use of chemicals. The Fish Creek Plant has an average design capacity of 72,000 m^3 per day and provides tertiary treatment for phosphorus removal. Chlorine is no longer used to disinfect the water for bacteria, viruses and other pathogens; both plants now use ultraviolet light. Calgary is currently in the planning stages for the new Pine Creek WWTP that will service the growing population in the south end of the city.

Industries

Industrial uses of water from the Bow River Basin are varied. They include aggregate washing and cement production, fertilizer production, greenhouses, feedlots, oilfield injection, gas plant/petrochemical production, and industrial processing. While some of these industries represent consumptive use of the river (e.g. oilfield injection), the majority return at least some flows to the river in the form of treated effluent. Like municipal wastewaters, industrial wastewaters must meet effluent quality regulations prior to discharge. Though there are cases of industrial land pollution that have contaminated groundwater or surface waters in the Bow River Basin, most industries no longer discharge to the river and contaminated sites are being restored.[217]

Effluent Dilution

Many municipalities and industries release effluents directly into the Bow River Basin. Indirect, or non-point source runoff results from a variety of land uses, such as golf courses, forestry and agriculture. Both these types of discharge contain higher concentrations of pollutants than the receiving waters. As a result, sufficient flows in the receiving river are required to dilute the effluent to a point where downstream water quality and aquatic resources are not impaired.

The natural flows of the Bow River are occasionally too low for sufficient assimilation capacity during the winter months. Enhancement of these naturally low flows is achieved by the regulation of the Bow River. Releases of water from hydroelectric facilities and dams during the winter allow cities like Calgary to meet effluent quality guidelines. However, with increases in population, agriculture and industrial activities, Bow River flows for waste assimilation will theoretically need to increase as well.[90] Unless improvements in the quality of effluent and runoff are synchronized with these increasing discharges, this situation will result in impaired water quality in the Bow River.

Bonnybrook Wastewater Treatment Plant – City of Calgary

Recreation

The Bow River Basin contains highly valued recreational resources. Used by boaters, canoeists, kayakers, whitewater rafters, and anglers, the Bow, Kananaskis, Elbow, and Highwood rivers are extremely popular with residents and tourists. The steeper, swifter, upper reaches of the rivers are ideal for advanced whitewater paddling. As the gradients decrease, the rivers are suitable for all paddlers.[119] The reach of the river below Calgary is internationally known as one of Canada's top trout fisheries.

The regulated flows of the Bow River have both facilitated and hindered recreational use of the river. Increased winter flows from reservoir releases have improved fish habitat, particularly downstream of Calgary, and have contributed to the excellent fishery.[90] During the summer, releases from the reservoirs allow sufficient water levels for recreational use of the rivers. Barrier Lake and the Ghost and Glenmore reservoirs provide additional recreational opportunities; Canoe Meadows on the Kananaskis River hosts international paddling events.[119]

Upstream of the Bearspaw Dam, hydro-peaking during times of peak electrical demand can place recreational users in some danger. The WID and Carseland weirs are extremely dangerous to swimmers and paddlers and must not be approached. A concerted effort is being made to plan for and finance a modification to the WID weir that will result in reduced dangers and potentially open up this stretch of the river to recreational users. Due to increased withdrawals, flows downstream of the Bassano Dam are often too low for recreational use and also stress the fishery. The growing population in the province can be expected to increase recreational demands on the river [119] and within the basin in general.

2.9 Land Use

Historic and present land use in the Bow River Basin includes grazing, agriculture, industrial and urban development. Table 2.8 lists the relative proportions of the major land use classes for the basin. The land use changes gradually from minimal use in the upper, forested headwaters of the basin, to agricultural use in the lower prairie reaches (Figure 2.7). The City of Calgary occupies a large area of urban land in the middle of the basin, and smaller communities are found along the river's mainstem and tributaries.

Several parks and protected areas are found throughout the Bow River Basin, and total 6,440 km^2 (25.63%). In 1987, the United Nation's Brundtland Commission identified protected areas as one of the fundamental tenets of sustainable development, suggesting that the percentage of protected areas should be set at a minimum of 12%.[62] Achieving a certain percentage, however, may not be as important as ensuring that representative ecosystems are adequately included for protection.

Table 2.8 Generalized land use in the Bow River Basin[6 39 254]

Reach	Area (km^2)	Crops (%)	Forage (%)	Grassland (%)	Shrubs (%)	Trees (%)	Forestry Cutblocks[a] (%)	Water (%)	Rock (%)	Snow/Ice (%)	Avalanche (%)	Urban[b] (%)
1	418	0	0	0.05	9.17	38.07	0	2.47	38.23	4.80	7.21	N/A
2	2,843	0.01	N/A	2.68	14.73	42.95	0	1.38	32.94	0.41	4.89	N/A
3	4,453	5.93	N/A	11.85	14.30	44.67	0.11	1.36	19.42	0.46	1.53	0.83
4	2,363	19.05	5.80	26.40	5.78	24.21	0.55	0.35	9.56	0	0.34	8.24
5	1,137	27.02	4.69	41.47	0.19	15.06	0.52	1.03	0	0	0	10.55
6	4,387	16.47	4.16	31.89	8.39	31.65	0.5	0.56	5.33	0	1.03	0.32
7	4,291	66.43	4.64	26.88	0.37	0.23	0	1.25	0	0	0	0.20
8	5,231	16.55	7.46	71.56	0.17	0.04	0	4.17	0	0	0	0.05
Total	**25,123**	**21.92**	**3.90**	**32.44**	**6.33**	**21.53**	**0.18**	**1.73**	**9.44**	**0.20**	**1.13**	**1.38**

N/A – data not available

[a] Forestry cutblocks were calculated by selecting all clearcuts less than 10 years of age (to account for regeneration)

[b] Urban land use includes the area comprising hard surfaces such as roads, houses, building, sidewalks, gravel etc. and does not include the full urban footprint, which can also include grassland, shrubs, trees, water etc. For this reason, the urban land use in this table is not equivalent to the size of the urban footprints discussed in the reach chapters.

The protected areas within the Bow River Basin are concentrated in the western portion of the basin, in the mountains and foothills. Banff National Park includes the entire headwaters of the basin, from its origins at Bow Lake to just upstream of Canmore. Several of these parks have been created since 1992, indicating an enhanced level of protection of these lands compared to the previous State of the Bow River report.[57] However, there is far less protected land in the eastern portion of the basin. Due to agricultural and urban development there is also less land suitable for protection.

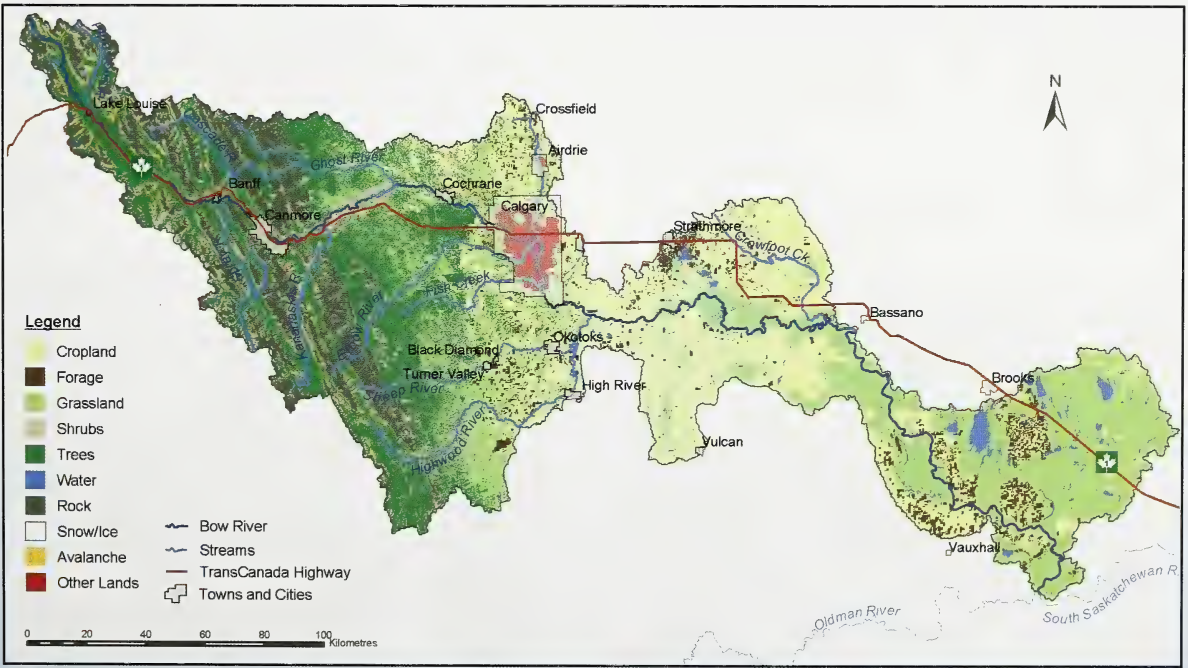
The types of human use and activities permitted within these parks and protected areas vary. While some areas restrict, or carefully control, human use, others are designated as multi-use and can include timber harvesting, petroleum development, livestock grazing, hydroelectric power generation, and developed recreational activities. Watershed protection is integrated with the management of several of these areas. The importance of headwaters protection, including native vegetation and ecological function, is a key to maintaining streamflows and the water quality of the basin. Watershed protection is integral to ensuring safe, reliable sources of drinking water.

Urban development comprises 346 km^2 (1.38%) of the landbase throughout the Bow River Basin, the majority of which is the City of Calgary. One of the greatest impacts of urban development is the significantly higher stormwater runoff volumes, relative to those generated from the forest or prairie ecosystems they replace. Impermeable surfaces such as roofs, roads and patios reduce the amount of ground infiltration and are connected to the rivers via the storm sewer system. In a watershed dominated by meltwater events, such as the Bow River, the high volumes generated by stormwater flows are not consistent with natural events. Following the spring freshet period, urban runoff from precipitation events produces unseasonably high flows in receiving streams.[161]

Traditionally, urban stormwater management has focused on removing precipitation from the urban environment as fast as possible. This approach increases the peak flows and total volume and reduces the water quality in the receiving streams. Recent changes to provincial regulations require urban areas in Alberta to make improvements to the quality and quantity of urban runoff.

Approximately 4,940 km^2 (19.66%) of the Bow River Basin is part of the Forest Reserve. Spray Lake Sawmills, which operates out of Cochrane, has a Forest Management Agreement (FMA) with the Government of Alberta from 2001 to 2021. This FMA encompasses 3,374 km^2, including 2,040 km^2 within the Bow River Basin.[41] Spray Lake Sawmills is currently developing a Detailed Forest Management Plan that covers harvest planning and operations, sustainability and forest

Figure 2.7 Generalized land use in the Bow River Basin[6 39 254]



management within this area. Spray Lake Sawmills has been conducting aquatic monitoring programs within their operating area since 1996.

Forestry activities within a watershed can influence the water quantity of a stream in several ways. Reductions in the amount of vegetated cover on the landbase, including trees, decrease the amount of precipitation that is intercepted prior to reaching the ground, and increase the rate and volume of surface water runoff. These changes are often manifested as decreases in low flows and increases in peak flows of the streams.[72 145] As an area is reforested, however, the land is able to return to a more natural vegetated state.

Approximately 6487 km^2 (25.82%) of the landbase within the Bow River Basin has been cleared for agricultural crops, with additional lands used for grazing. The livestock population includes cattle, horses, chickens, pigs, sheep, bison and other diversified livestock, but numbers within the basin are not available.[137] The emphasis on livestock operations, particularly feedlots and dairies, can influence water quantity and quality in several ways. Intensive grazing can compact soils, reducing their natural infiltration capabilities and increasing runoff.[245] A single feedlot animal can drink up to 50 L of water a day and a lactating dairy cow twice that much.[15]

Forage crops are the largest agricultural group, with cereals a close second. Both are grown as dryland and irrigated crops. Where irrigation is not available, cereals play a larger role. Feed barley, prairie spring wheat and hard spring wheat are the most significant cereal crops in both the dryland and irrigated portions. Conventional tillage injects oxygen into the soil, which accelerates the decomposition of organic matter. When tilled, soils with low organic matter tend to form a hard pan, often called a plow layer. Soils in the Bow River Basin that are low in organic mater, with a high clay component, may compact thus reducing their natural infiltration capabilities and increasing runoff.[245]

Agricultural development within this reach has also led to the drainage and conversion of wetlands. The loss of wetlands can affect water quality and quantity; wetlands remove sediments and nutrients, recharge groundwater levels, and are a key to protecting the flows and integrity of the Bow River watershed. However, it is important to note that wetland habitat has also been created within this reach, as part of the irrigation canals and reservoirs.

2.10 Water Management

The management of water in the Bow River Basin is shared by several jurisdictions and is based on many policies, laws, licences, and approvals. The Albertan and Canadian governments, First Nations, municipalities, and irrigation districts all have responsibilities to protect and manage water in their particular sphere of influence.

These jurisdictions are responsible for a wide range of water management practices, most of which can only be touched on in this report. Areas key to the appropriate and responsible management of water include:

- Licences, approvals and authorizations (e.g. water withdrawals; authorization for the harmful alteration, disruption or destruction of fish habitat)
- Water management facilities (e.g. irrigation headworks and canals; water and wastewater treatment plants)
- Environmental assessment, monitoring and enforcement (e.g. long-term river network water quality monitoring)
- Protection, conservation and improvement (e.g. non-governmental organizations; municipalities)
- Education, training and information exchange (e.g. universities; non-profit organizations)


AAFRD


AAFRD


AAFRD

Licensing Agreements

The Government of Alberta is responsible for issuing licences for water use. Licensees have the right to use the quantity of water specified in their licence, under specific terms and conditions. If a shortage of water results in insufficient water to satisfy the requirements of all licensees, the Alberta *Water Act* allocates water according to the principle of "first in time, first in right."[25] The earliest licensee is entitled to receive the entire quantity of water in their licence before the next licensee can receive any water at all, and so on. Requiring licensees to shut off or reduce their diversions in reverse order of seniority helps enforce the principle. This issue can become complicated when downstream users have a prior legal right to water ahead of licensed users upstream.

Because of the variability in natural flows of the Bow River, licences for water allocation have occasionally exceeded the actual availability in the river. The combination of increasing numbers of licences, increased use of allocated water by licensees and a low flow or drought year could affect many municipalities, industries and farmers under the priority system. When water shortages occur, either the priority system comes into effect, or licensees can share water.

Assessment of water management issues and the availability of flows for future allocations is being carried out by the South Saskatchewan River Basin Water Management Plan (SSRB WMP). Phase I of SSRB WMP developed a system of water allocation transfers allowing allocations within the SSRB to be moved where most highly valued. It is hoped that through these transfers, water may be used more efficiently, making water available for new users. The transfer of senior water licences to junior users may be useful in meeting changing water demands.

By holding back up to 10% of all transfers, additional flows may be returned to the river under future arrangements. However, given its value, it is unlikely that large transfers of water will take place, reducing the likelihood of restoring additional flows to the Bow River. irrigation districts, which have the largest allocations, are unlikely to transfer a portion of their licence, reducing the likelihood of restoring additional flows to the Bow River.[25]

Ultimately, however, it will be the watershed councils (such as the BRBC) that will be responsible for resolving or recommending solutions to water management issues.

An inter-provincial agreement, called the Master Agreement of Apportionment, also plays a role in management of the Bow River. The Bow River is part of the South Saskatchewan River Basin, which spans Alberta and Saskatchewan. Under this agreement, signed in 1969, half the natural flows of the South Saskatchewan River must flow from Alberta into Saskatchewan every year. The exception to this is that Alberta is entitled to divert, store or consume at least 2,590 million m^3 each year. When the annual volume of natural flows is less than 5,180 million m^3, then Alberta is permitted to take its minimum flows and allow less than half the natural flows to enter Saskatchewan.

This commitment requires the Bow River to be managed in collaboration with the other parts of the South Saskatchewan River Basin. For example, the Red Deer River is currently less utilized, so its flows are occasionally used to make up the differences created by heavy utilization of the Bow and Oldman rivers. The importance of the Red Deer River's contributions is expected to increase in the future as licensees in the Bow River Basin use more of their allocation.

Instream Flow Needs

Aquatic ecosystems require a certain quantity and quality of water to maintain their ecological integrity, structure and function, and to ensure their sustainability. These ecosystem requirements can be referred to as instream flow needs. The consideration of instream flow needs in water management of the Bow River Basin will provide decision makers with better information when considering applications for water withdrawals or effluent discharge. This information could also be useful for the most effective operations of dams, weirs and WWTPs and lead to increased health of the aquatic environment.

Phase II of the SSRB WMP is currently determining the flows required within the Bow River to meet both human demands and the requirements of the aquatic environment. It is scheduled for completion in 2005. As part of the SSRB WMP, the Government of Alberta will set water conservation objectives for specific reaches of the Bow River.

Water conservation objectives attempt to find a balance between water consumption and environmental protection of the river, and will determine the maximum amount of water that can be allocated. Ultimately, the water conservation objectives will establish the quantity and quality of water required to protect the river, including its tourism, recreational, and waste assimilation uses, as well as for management of its fish and wildlife.[24]

Until the water conservation objectives are set, Alberta Environment has developed interim flow requirements for some sections of the Bow River and

its tributaries. For example, instream objectives have been determined for the river between the Ghost Dam and the Bassano Dam.[28] Minimum flows as conditions of licences have also been established between the Bassano Dam and the river's mouth.

Instream flow needs have recently been determined for the lower reaches of the Bow River (from the WID weir to the Bassano Dam) based on four ecological criteria: water quality, fish habitat, riparian vegetation, and channel maintenance. These instream flows needs are based on the natural flow paradigm, whereby the river system is adapted to, and dependent on, the natural range of flow variability to sustain ecological processes and diversity within the system.[90] The instream flows needs are one of the factors considered in the establishment of water conservation objectives. Social and economic factors are also considered.

Comprehensive Planning

Communication and collaboration among those involved in water management are essential to ensure the responsible use and conservation of water resources. The sustainability of the natural environment and the social and economic futures of its human population are dependent on the management philosophies and approaches. Current and evolving needs must be met without compromising the ability of future generations to meet their own needs. The challenge will be to ensure adequate supplies of water for ecosystem requirements, while the demands on water for human uses continue to grow.

The Government of Alberta plans to meet this challenge. In 2003, it developed a comprehensive strategy called *Water for Life: Alberta's Strategy for Sustainability*.[128] This document recognizes that population growth, droughts and agricultural and industrial development are increasing the demands and pressures on the province's water supplies. Subsequently, risks to the health and well being of Albertans, to the economy and to aquatic ecosystems are also increasing. In the past, Alberta has been able to manage the water supply because there has been a relatively abundant, clean supply to meet the needs of communities and the economy. However, fluctuating and unpredictable water supply in recent years has increased the need to make some major shifts in Alberta's approach to managing this renewable, but finite, resource.

Chapter 3

Herbert Lake - B.Coffey

Chapter 3

Reach 1 – Bow Lake to Lake Louise

3.1 What is in this Reach?

The Bow River originates from the melting of the snowcaps and icefields, including Bow Glacier, on the east slopes of the continental divide of the Rocky Mountains. These meltwaters form Bow Lake, which is approximately 309 hectares (ha) in size. Leaving Bow Lake, the Bow River flows through the mountain valley, then enters and exits Hector Lake. Reach 1 ends at the community of Lake Louise. This reach of the Bow River is the smallest, at just 51 kilometres (km) in length, and drains an area of approximately 418 square kilometres (km^2) (Figure 3.1). Several small tributaries contribute to the flows of the Bow River in this reach, including Bath Creek. Hector Lake is the largest lake at approximately 546 ha.

Located entirely within Banff National Park (BNP), the landscape is comprised of spectacular mountains, glaciers and steep valleys. The vegetation varies with elevation, from high alpine peaks above the treeline to the sub-alpine region in the river valley. The alpine meadows provide habitat for a variety of large and small mammals, including grizzly bear, mountain goat, and bighorn sheep. Black bear, lynx, wolverine, elk, snowshoe hare, and red squirrel can be found in the lower elevation pine, spruce and sub-alpine fir forests.

The river valley is an essential wildlife movement route through the mountains, but human development and activities have compromised this function. While wetlands are limited, due to the high gradient of the river in this reach, several lakes provide still-water habitat for migratory birds and waterfowl. Native fish species within this reach include bull and westslope cutthroat trout, but, their populations face continued pressure from introductions of non-native fish.

Compared to downstream reaches, the Bow River Basin exists in a relatively natural state, with 98.8% of the landbase undisturbed (Figure 3.2). The greatest human influences on the river are linear developments. Highway 93 parallels the river throughout this reach, while the TransCanada Highway (TCH) and Canadian Pacific Railway (CPR) both cross the river near the community of Lake Louise. The CPR and TCH are located only in the lower extent of this reach, exerting minimal direct influence on this portion of the basin.

The major land issues are recreation and tourism-related activities. These are concentrated along access points (highways and trails), resulting in minimal

Figure 3.1 Overview map of Reach 1[16 39 45]

changes to the landbase compared to downstream reaches. There are no permanent urban centres, but several cabins, hostels and lodges accommodate visitors, particularly during the summer. Tourists and recreational visitors, both local and international, participate in backcountry hiking, camping, mountain biking, cross-country skiing, and fishing.

While it is difficult to determine precise numbers of visitors, summer traffic volumes reach 4,000 vehicles a day on Highway 93,[181] and average 1,000 vehicles per day on an annual basis.[178] Tourism and road traffic is substantially lower than in Reach 2, with the majority of traffic continuing on the TCH, rather than following Highway 93.

No major water withdrawals are licensed for this reach, and domestic and industrial withdrawals and discharges are minimal, consisting primarily of small tourist facilities.

Figure 3.2 Land use of Reach 1[39 45 254]

3.2 Hydrology

In the upper reach of the Bow River Basin, the majority of the annual flow volume originates from melting snow and ice during the spring, summer and early fall.[257] This seasonal pattern is illustrated by the natural flow curve in Figure 3.3, which depicts the average discharge for the *Bow River at Lake Louise* (Water Survey of Canada Station AB05BA001) (Figure 3.4, page 48).[29] Natural streamflows peak at an average of 30 cubic metres per second (m^3/s). Baseflows, which consist mainly of groundwater, occur from November to April and average between 1.5 and 2 m^3/s.

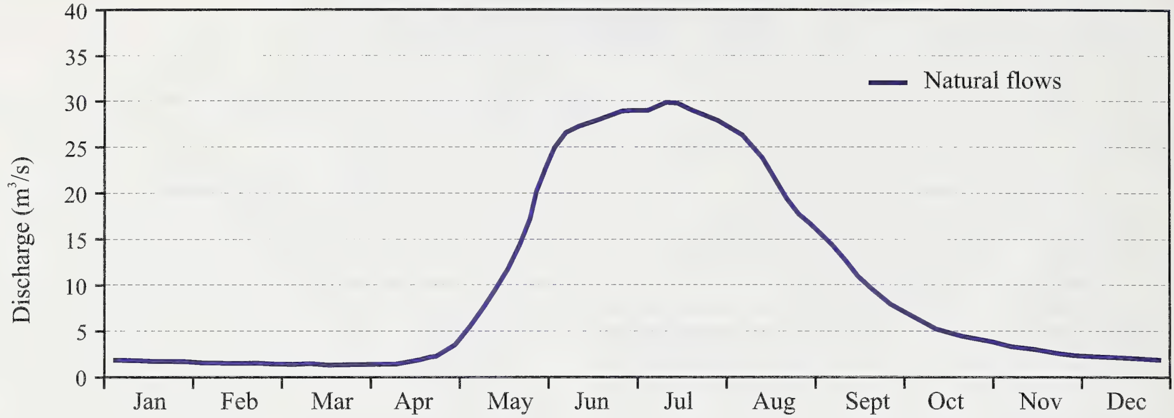
Within this reach, the recorded and natural flows of the river are essentially the same since no meaningful allocation for diversion or water storage takes place. Flows are generally unimpacted by human activities. A few extractions for small tourism operators are licensed in Reach 1, but these have no measurable impact at the monitoring station on the flow regime, water quality or habitat for riparian vegetation and aquatic animals.

Over the last few decades, glaciers in the Rocky Mountains, including those in the headwaters of the Bow River, have been receding (see Chapter 2).[257] The Bow Glacier has receded by at least 1,500 m.[205] If the glaciers continue to melt at this rate, increased flows would be expected during the summer. However, continued melting and glacial retreat would eventually result in less water being available to supplement streamflows.[138] Because glacial melt is a significant source of seasonal flows in the Bow River's headwaters, substantial impacts on summer flows may occur in Reach 1.

3.3 Water Quality

Water quality in the Bow River is measured by Environment Canada at one site within Reach 1. The site is named *Bow River above Lake Louise* (Site 00AL05BA0011) and is located at the TCH bridge, approximately 2.7 km upstream of the Hamlet of Lake Louise (Figure 3.4). Overall, the water

Figure 3.3 Discharge of the Bow River at Lake Louise (1971-2001)[29]



quality in Reach 1 has not been adversely affected by any point source inputs or major sources of contaminants and is considered to be of relatively high quality compared to downstream reaches.[120]

In general, the Bow River in Reach 1 is cold and clear. Its turbulent, fast flows ensure that it remains well-oxygenated for most of the year.[55 109] Since the solubility of oxygen decreases with temperature, the lowest concentrations are found during the summer months, when the water is warmest. These lower readings are entirely natural and are not expected to pose any threat to aquatic life.

The emerald hue of Bow and Hector lakes is caused by light reflection from suspended glacial silt or flour, which consists of very fine particles of rock that are ground loose and naturally released from the melting glaciers. Much of this glacial debris settles in a pond at the foot of Bow Glacier and in Bow and Hector lakes, resulting in the majority of the Bow River containing very low sediment levels, even during spring runoff.[55 120]

The dissolved ion content of the river is also low in this reach, with moderately soft water. Ion concentrations increase during the winter, when groundwater supplies most of the streamflow. Groundwater tends to be more highly mineralized than surface waters derived from snowmelt.[55 120] Over the period of record (1983 to 2002), the concentrations of several major ions have increased significantly. The increases in some ions (e.g. fluoride, magnesium) may be due to climatic and hydrologic variability, with lower winter snowfalls during the latter part of the monitoring period potentially resulting in lower spring runoff and decreased dilution of ions.

Increased sodium and chloride concentrations, however, are likely due to human influences. Seepage from septic tanks[200] and road salting on Highway 93 may contribute to increasing concentrations. Road salts are used as de-icing and anti-icing chemicals for winter road maintenance and have been implicated in harmful effects on riparian vegetation and aquatic organisms.[111] Road salts have been recommended for addition to the

Bow River and Heart Mountain – H. Unger

toxic substances list under the *Canadian Environmental Protection Act*, which, if approved, would result in limits on their release to the environment.[98]

The headwaters of the Bow River Basin are oligotrophic and naturally very low in nutrients like total phosphorus and nitrogen.[55 120] These nutrients, in particular, phosphorus, limit the productivity of the aquatic system.[58 209] Concentrations of total phosphorus naturally increase during spring runoff. Within Reach 1, total phosphorus is primarily in its particulate form (from weathering of apatite rocks), and is not readily available for use by aquatic communities.[55 120] Dissolved concentrations of phosphorus, which can stimulate aquatic plant growth, are very low. The Bow River likely receives some nutrients from septic tanks on Bow Lake and other campground facilities, but total phosphorus concentrations above Lake Louise are often undetectable.[207]

Bacterial concentrations are also very low at the headwaters of the Bow River.[120] While some bacteria are naturally found in soils and enter the water through surface runoff, the occasional presence of fecal coliforms indicates contamination by wildlife or human wastes. As a result, no untreated surface waters are safe to drink. Adequate treatment, either via a water treatment facility or through boiling, chemical treatment and/or filtering when in the backcountry, is necessary to avoid gastrointestinal illness.

Why are industrial pollutants found in the Rocky Mountains?

Long-range atmospheric transport and deposition of pollutants have reached even the most remote locations. Several industrial pollutants and agricultural pesticides have been confirmed in Bow Lake. These persistent organic pollutants (POPs) include a large set of compounds such as organochlorines (OCs), DDT and PCBs.[53]

Once within the lakes, the POPs travel through the food chain. These compounds are present primarily in a bio-available form, easily taken up by aquatic organisms.[illegible] In Bow Lake, tiny zooplankton ingest and store the POPs. When fish eat the zooplankton, the POPs are concentrated in their tissues at increasing levels. Lake trout from Bow Lake, in particular, were found to have some of the highest concentrations of toxaphene, an agricultural pesticide, of 14 lakes studied in western Canada.[illegible] Because people do not consume large amounts of fish from Bow Lake, the concentrations in these fish are not considered a human health risk.[182]

This pollution issue is not confined to the Bow River watershed. Alpine and arctic regions throughout the world have recorded the presence of pollutants that, despite no local sources, are being deposited in these remote areas. When used or applied to the land in warm regions (tropics and subtropics, and in temperate regions during warm summers), these chemicals evaporate into the atmosphere. When the air containing these chemicals reaches higher elevations it cools and falls as precipitation, accumulating as high alpine snow and ice on the peaks of the Rocky Mountains. The compounds are released into flowing waters when the ice and snows melt.[54]

Some of these compounds have decreased over the past few decades, presumably the result of restrictions or bans placed on their manufacture and use in North America and other continents.[103] DDT and PCBs, for example, are no longer used in many countries. However, some chemicals banned by Western countries are still used in developing areas. The snow and glacial ice in the arctic and high altitude alpine areas will continue to release these POPs into aquatic environments until their historical accruals are gone and contaminants are no longer being accumulated.[103 182]

Dissolved metals concentrations, generally the most bio-available form, were very low at this site. Dissolved lead concentrations were occasionally elevated, however, these levels are considered natural. Total metals and pesticides were not included in Environment Canada's monitoring program above Lake Louise, due to the lack of agricultural practices and permanent occupation.

While the water quality at the headwaters of the Bow River is excellent, it cannot be considered pristine. Glacial ice, water and fish samples taken near the headwaters of the Bow River confirm the presence of several pesticides and persistent organic pollutants.[53 64] Relative to the downstream reaches, there are few other impacts on water quality from human activities. There are no direct municipal or industrial discharges to the Bow River, but small point sources or indirect inputs occur along the reach. These inputs include seepage from septic tanks at outlying areas and campgrounds, which may contribute nutrients and bacteria.[208] Runoff from highways, roads and trails includes sediment, hydrocarbons and road salts. These non-point source influences are difficult to quantify, and little specific information exists regarding their impact on water quality of the Bow River.

3.4 Ecosystems

Terrestrial Habitat

Terrain and habitat in Reach 1 ranges from steep mountain peaks and glaciers, to deep lakes, meadows and swift-running waters (Table 3.1). The Wapta Icefield to the west of the headwaters of the Bow River contains several glaciers, including the Bow Glacier, which carved out the Bow Valley between Banff and Bow Lake over 10,000 years ago. The peaks of the Bow River Basin's headwaters are located in the alpine natural region, which gradually makes a transition to the sub-alpine natural region in the lower valleys (Figure 3.4).[19] The location of the treeline between the alpine and sub-alpine natural regions depends on climate change and extreme weather events. Comparisons with historical photographs from the 1880s indicate recent warmer temperatures are causing the treeline to advance upslope.[181]

Most of the alpine areas contain very little soil. This factor, along with micro-climatic conditions such as aspect, wind exposure, snow depth and timing of snowmelt, limits alpine plant communities. Despite these restrictive conditions, hardy, low-growing sedges, heathers and grasses comprise diverse and colourful alpine meadows.[19] While trees are absent in the alpine areas, willows and other dwarf shrubs can be found in moister spots.[227]

Conifers dominate the sub-alpine landscape. At the upper extent of the sub-alpine, scattered *krummholz* can be found. This term describes trees that have developed into low, twisted, shrub-like forms as a result of the harsh environmental conditions, especially prevailing winds. Engelmann spruce and sub-alpine fir forests typically occur on higher, moister sites that have not been subjected to fire. The lower sub-alpine is characterized by closed forests of lodgepole pine, Engelmann spruce and sub-alpine fir.[19] Deciduous trees occur in warmer areas; willow and alder shrubs occupy poorly drained sites. Scattered on the steep west- and south-facing slopes are grassland communities of fescue, wild rye and wheat grass. A diverse mix of shrubs can be found on avalanche-prone slopes.[19]

Figure 3.4 Natural sub-regions and measuring locations of Reach 1[23 39 40 45 195]

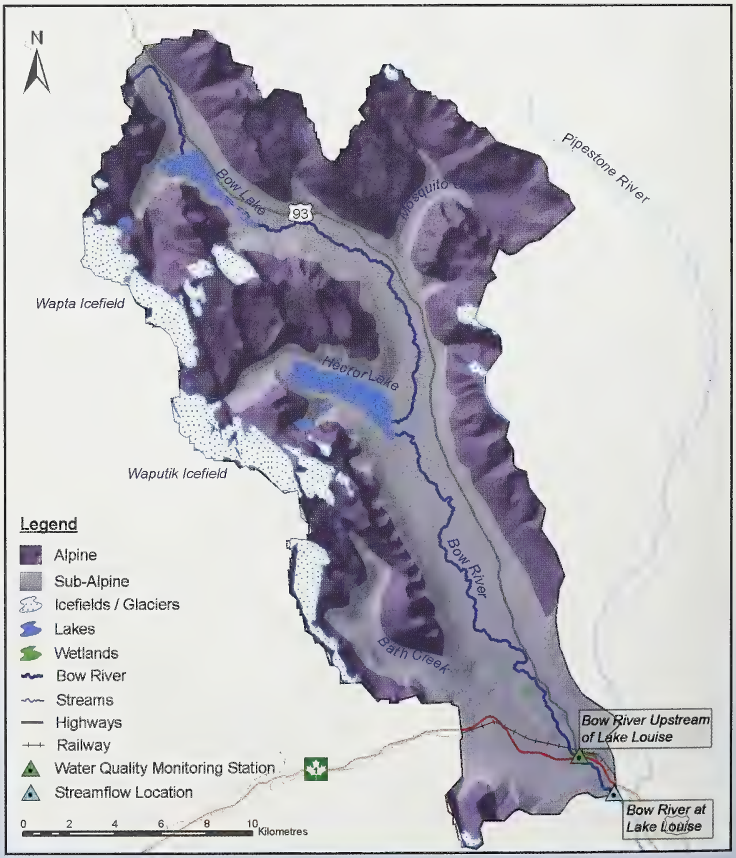


Table 3.1 Size and extent of Reach 1 features [23 39 40 45 195]

Natural Feature	Area (km^2)	Extent of Reach (%)
Icefields	32	7.73
Alpine sub-region	207	49.63
Sub-alpine sub-region	166	39.79
Lakes	10	2.44
Wetlands	1	0.13
Rivers	1	0.30
Total	**417**	**100.00**

Near Lake Louise, sub-alpine larches provide spectacular colour in the lower valley as their needles change to gold during the fall.

The expanse and variety of habitat supports many species of wildlife. The alpine region provides habitat for grizzly bear, mountain goat, and bighorn sheep. Rock fields near the treeline and scree slopes are used by ground squirrels, chipmunks, pika, and hoary marmot. Birds, including the white-tailed ptarmigan and gray-crowned rosy finch, are found in alpine areas only during the nesting season. The sub-alpine areas provide a transition from the alpine to the lower montane region and provide habitat for the above-mentioned animals as well as black bear, lynx, wolverine, elk, snowshoe hare, and red squirrel.[19]

Along Highway 93, vehicle traffic, outlying commercial operations and parking congestion pose obstacles to wildlife movements.[143] Human activity has negatively impacted prime grizzly bear habitat, particularly during the summer months.[157] Despite these pressures, the group of grizzly bears studied in the Bow River Basin have shown positive population growth over the last decade, but this increase may be difficult to maintain due to the cumulative effects of increasing human population and development.[134] The mountain goat is also being studied due to the sharp decline in its population since the 1990s.[181]

Virtually the entire landbase is considered environmentally significant – internationally, nationally or regionally. The Bow Valley is considered an internationally significant wildlife migration corridor and the Bow River is renowned for its important fish habitat. The Lake Louise area is considered significant for its critical grizzly bear, elk, lynx, bighorn sheep and mountain goat habitat.[181 232]

Riparian and Wetland Habitat

The riparian areas along Reach 1 of the Bow River, are dominated by a mixture of dense and open stands of Englemann spruce and white spruce hybrids.[19] The riparian area may be assumed to be healthy and relatively unimpacted by human activities compared to downstream reaches. The minimal water extractions that occur within this reach likely have no impact on the overall riparian health of the Bow River. Flooding along the Bow River and its tributaries is an integral component of the aquatic and riparian systems. Highway 93, where it parallels the mainstem, impinges on the natural floodplain of the Bow River.

Due to the high gradient of the Bow River, there is little wetland habitat, however, lakes provide still-water habitat. The lakes were carved by glaciers and are also found in pre-glacial valleys. Non-peat wetlands are found in valley bottoms and depressions.[35] Bow and Hector lakes provide some nesting habitat for waterfowl. Migratory birds use the open waters of the Bow River, as well as several shallow lakes and ponds en route to nesting grounds. These ponds also provide significant habitat for the Columbia spotted frog.[232] American dippers and harlequin ducks are found along fast-flowing sections of the mainstem and its tributaries.[19] The harlequin is the only duck in North

Elk – A.Mackeigan

Grizzly Bear – A.Mackeigan

Big Horn Sheep – A.Mackeigan

America that migrates from the sea to nest along mountain streams during the summer,[213] with approximately 150 found in the Lake Louise area.[181] The harlequin duck and Columbia spotted frog are listed as "sensitive" in Alberta.[44]

Aquatic Habitat

The upper reach of the Bow River is cold, clear and well-oxygenated. Nutrient concentrations in the water are low, limiting aquatic plant growth and benthic invertebrate communities. Like many high mountain streams, the benthic plant and animal communities of the Bow River are subject to severe scouring every spring runoff. Consequently, the overall productivity of Reach 1 is low, resulting in relatively low fish populations compared to the downstream reaches. Many of the high-elevation tributaries are devoid of fish, due to the steep gradient and presence of impassable waterfalls. Some lakes were also originally fishless, but were stocked years ago.[164] Despite limitations to habitat and productivity, Reach 1 still supports a wide variety of native and introduced cold-water fish species.

Native species found throughout much of the mainstem of the river and some of its tributaries include cutthroat trout, bull trout and mountain whitefish. Mountain whitefish is the most abundant and spawns throughout the mainstem of the Bow River. Brook trout, an introduced species, is the second most abundant sportfish species in Reach 1. It has been known to spawn at the outlet of Hector Lake, in Bath Creek and in the upper mainstem of the Bow River.[105] The fish populations of Bow and Hector lakes include cutthroat, rainbow, brook and lake trout as well as mountain whitefish.[68] The presence of longnose sucker and brook stickleback is likely in deep lakes and flowing waters, respectively.[172]

Bull and westslope cutthroat trout were historically the most common trout within the Bow River along the eastern slopes of the Rocky Mountains, extending up to the headwaters above Bow Lake.[164] Due to habitat impairment, overfishing and non-native fish introductions, their populations and distribution have decreased substantially over the last century.[208] Population declines for these two species were observed as early as 1910.[207] The bull trout is listed as "sensitive" within Alberta (see Chapter 2), and all bull trout caught must be released. While the status of the cutthroat trout is listed as "secure", all cutthroat trout caught within BNP must be released.[44]

Today, Reach 1 is virtually the only section of the Bow River in which cutthroat trout can be found in the mainstem. The upper tributaries and a few lakes also contain native stocks of cutthroat trout, however, hybridization with non-native rainbow and Yellowstone cutthroat trout have led to few remaining pure stocks.[163] The bull trout population has also declined since historic times. In Reach 1, bull trout are now found only in the headwaters and upper tributaries and in a reduced number of cold mountain lakes.[164] They are known to spawn in Bath Creek, which appears to have one of the healthiest populations.[60, 105] Bull trout have been eliminated from both Bow and Hector lakes, presumably as a result of competition from introduced lake trout.[165] Hybridization with the introduced brook trout, which can now be found in 100% of the bull trout's historical distribution, has also led to its decline.[208]

The establishment of fish populations in previously fishless lakes in BNP has had significant impacts on native invertebrate populations. In fishless alpine and sub-alpine lakes, the top predator within the aquatic food web is often a large shrimp-like crustacean. The addition of fish has eliminated the crustacean and insect larvae populations and permanently changed the ecosystem, even when the stocked fish did not survive. The reduction or elimination of the native invertebrates in some of these fishless lakes has allowed algae to flourish, possibly reducing the lakes' clarity.[208]

Lake Louise - Mike Murray

3.5 How do Land Use and Management Policies Affect this Reach?

Natural disturbances are an integral component of ecosystem function and structure within the watershed of Reach 1. Fires from lightning strikes have long been a part of natural disturbances in the Bow Valley and were perhaps the most important influence on the vegetation of the sub-alpine region. Flooding along the Bow River and its tributaries is also essential for the maintenance of riparian and wetland communities. Avalanches clear areas of trees and shrubs, opening them up for new growth that is essential for wildlife habitat. Some level of insect infestations and disease is natural and part of the ongoing renewal of these ecosystems.[50]

In comparison to the eastern portion of BNP and downstream reaches, the western headwaters of the Bow River Basin are less heavily used.[183] However, humans have added new stresses and cumulative impacts on the environment. Historically, First Nations people started fires throughout the Bow Valley to encourage new growth.[50] Since 1880, fire suppression has led to aging forests and changes to wildlife habitat.[181] Management attempts to replicate natural fires include prescribed burns, particularly in the watershed of Reach 2. Approximately 5 km^2 (1.2%) of the watershed of Reach 1 has been cleared for linear developments, tourism and recreational activities (Figure 3.2, page 45).

The human history of the upper Bow Valley reflects the changing values placed on its natural environment. First Nations people have used the river and its valley for more than 10,000 years. Prior to European settlement, it provided a natural strategic base and transportation route for people of the Blackfoot Nation. When the Bow Valley was selected as the route for the CPR in the late 1880s, the railway's construction established the first permanent occupation of the headwaters of the Bow River.[50]

Canada's first national park, BNP was established in 1885 as a tourism resort associated with the hot springs and railway. Today, the Bow Valley is the route of Highway 1, the national transportation corridor, increasing its accessibility to tourists and recreationists. Activities and developments, initially encouraged to bring in visitors and revenue, are now considered unacceptable by some people.[196] The federal government's position on BNP has also shifted. In the *Rocky Mountain Parks Act 1887* the parks were promoted as "primarily places of business." A 1911 policy statement declared, "there would be no business except such that is absolutely necessary for the recreation of the people." The *1988 National Parks Act* states that the "maintenance of ecological integrity through the protection of natural resources shall be the first priority." Debate on appropriate activities within a national park continues among governments, tourism operators and environmental groups.[50]

An example of these changing policies and priorities is provided by the history of fishing within BNP. Approximately 9,000 licensed anglers currently fish annually in BNP, a small portion of the estimated five million annual visitors to the park.[196] Fishing was promoted in BNP for most of the previous century, with lakes and streams deliberately stocked with non-native species in order to attract anglers.[208] Most fish stocking ceased in the 1970s (with the exception of reintroduction efforts) and in the 1980s, Parks Canada changed its policy to one that discourages, but still permits, fishing in BNP.[196] Catch and release fishing is promoted and the restoration of native species is now a priority. Similarly, hunting in BNP was prohibited in 1890, however, predator control programs did not end until 1959.[183]

Other indirect methods are being used to limit visitor access and associated impacts on the headwaters of the Bow River Basin. Maintenance of some rarely used backcountry roads, trails and cabins has ended and backcountry camping fees have been implemented.[117 183] According to Parks Canada's BNP Management Plan, if

Bow Riverkeeper

Bow Riverkeeper was founded by citizens of Alberta and is also part of an international alliance headed by Robert Kennedy Jr. and Waterkeepers Canada. Their mission is to protect and restore the Bow River watershed from its headwaters in Banff National Park to its confluence with the Oldman River. The Bow Riverkeeper program will monitor the Bow River and fill the niche of a full-time watchdog for the Bow River. The group is working closely with the river guiding (angling and rafting) community and the Siksika First Nation to develop a river monitoring network and promote watershed stewardship.

human uses are to continue, they must be done in a manner consistent with the mandate of conserving, maintaining and restoring ecological integrity within the park.[183] Undoubtedly, a complex mix of social, ecological and economic values exists within the headwaters of the Bow River Basin.

3.6 Where are we Headed?

Unlike downstream reaches, water use is not a concern in this reach. Water flows have not been impacted and vary negligibly from natural flows. Phase 2 of the South Saskatchewan River Basin's Water Management Plan (SSRB WMP) (see Chapter 2) did not recommend Water Conservation Objectives for Reach 1. The priorities were for those reaches of the Bow River downstream of major water withdrawals. Currently, flows within Reach 1 are adequate and provide the instream flow needs for water quality, fish habitat, riparian vegetation and channel maintenance. This source water protection is critical to the health of downstream reaches of the Bow River.

While changes to the landbase are not as great as in downstream reaches, human activities have impacted water quality and aquatic ecosystems. As described in Chapter 2, climate change scenarios predict increased glacial melt, resulting in continued release of stored organic pollutants into the headwaters of the Bow River. Continued research into native fish, specifically bull and cutthroat trout, will help define their current status and identify where reintroductions may be possible. Aquatic systems that may be closed to fishing in the future are being studied, as is the issue of how to restore naturally fishless lakes.[181 183]

While no permanent communities exist, tourism is expected to increase,[117] particularly along roadways and vehicle-accessible day use sites.[181] Overnight use continues to be low, but day use of trails is increasing. There has been a trend away from backcountry camping and toward the use of alpine huts since 1992.[181] In the future, recreational facilities at Bow Lake may be consolidated and wastewater facilities improved in order to reduce environmental impacts.[183] Future management will probably discourage increases in use and prohibit any expansion of commercial and non-profit guiding, except where there are demonstrable environmental benefits.[183]

However, continuing pressures on the watershed and aquatic resources necessitate the collection of comprehensive information on which to base predictions, measure responses and facilitate management decisions. Water quantity and water quality measurements are taken at one site each within this reach.

Alberta Environment is currently undertaking a four year study of glaciers in the South Saskatchewan River Basin (of which the Bow River Basin has the majority) to better understand the volume of glaciers lost during the last 50 years, and to generate better hydrologic models. Once the study is complete, climate change scenarios will be run to better predict changes that may result to glaciers and streamflows under global warming.[209]

Information gaps include riparian areas and impacts of small point-source and non-point sources of pollutants on water quality. Strategies to restore native fish populations and naturally fishless lakes are being implemented, requiring studies on the results. These data gaps represent opportunities to improve the understanding and management of the Bow River within Reach 1.

Chapter 4

Bow River and Banff Hoodoos – A.MacKeigan

Chapter 4

Reach 2 – Lake Louise to the Banff National Park Boundary

4.1 What is in this Reach?

Reach 2 of the Bow River is located entirely within Banff National Park (BNP). The upper end of the reach begins just above the Hamlet of Lake Louise, flows past the Town of Banff through the mountain valley and ends at the eastern boundary of BNP. Reach 2 is 82 kilometres (km) in length, and drains an area of approximately 2,843 square kilometres (km^2) (Figure 4.1). The major tributaries to the Bow River are the Pipestone, Spray and Cascade rivers. Smaller tributaries include Baker, Johnston, Redearth, Brewster, Forty Mile, and Carrot creeks. Other major aquatic features include several important wetlands, lakes and unique thermal springs, including Lake Louise, Moraine Lake, the Vermilion Wetlands, and the Sulphur Mountain Hot Springs. Lake Minnewanka, at 2,227 hectares (ha), is the largest lake.

The landscape is varied, consisting of steep mountain peaks sloping toward the broad Bow Valley. The vegetation varies with elevation, from high alpine peaks above the treeline, to the sub-alpine region along the base of the mountains, and the montane region in the river valley. The montane is the least extensive natural region in BNP, yet is the most biologically diverse and ecologically important.[50] It is also the focus of development and human use.

The alpine meadows provide habitat for a variety of large and small mammals, including the grizzly bear, mountain goat and bighorn sheep. Black bear, lynx, elk, coyote, and wolves are found in the sub-alpine and montane forests and river valleys. The Bow River Valley is an essential wildlife movement route through the mountains, but human development and activities have compromised this function. The wetlands and lakes provide habitat for migratory birds. Native fish species include bull and westslope cutthroat trout. However, their populations face continued pressure from habitat alterations and historical introductions of non-native fish. These pressures are also thought to have led to the extinction of an endemic species, the Banff longnose dace.

The majority (95.5%) of the landscape is in its natural state (Figure 4.2). Human activities and land use are concentrated along the river valley, but impact many critical natural areas. Human influences on the

Figure 4.1 Overview map of Reach 2[16 39 45]

river within Reach 2 include the communities of Lake Louise and Banff, hydroelectric production, recreational activities and linear developments. The TransCanada Highway (TCH) and Canadian Pacific Railway (CPR) parallel the Bow River throughout this reach. Plans to twin the TCH from Castle Junction to the western boundary of BNP are in the final stages. Concerns regarding human use include blockage of wildlife movement across the Bow Valley, altered predator-prey relationships, eutrophication of aquatic systems, introductions of non-native plants and fish, and loss of montane habitat due to development and fire suppression.[50]

Compared to annual visitor numbers to BNP, the permanent population in the communities of Lake Louise and Banff is small. Lake Louise has grown from fewer than 1,000 people in 1991 to a population of 1,497 in 2001 and has set a residential ceiling of approximately 2,200 people.[179] Banff has increased from 5,688 people in 1991 to a 2003 population of 8,282. It has a residential ceiling of fewer than 10,000 residents.[183] Banff cannot expand beyond its legislated boundaries and Lake Louise plans to shrink its boundaries by 37%, in order to protect wildlife movement corridors and riparian vegetation.[170] Both communities have a need-to-reside policy, limiting their use for holiday homes.

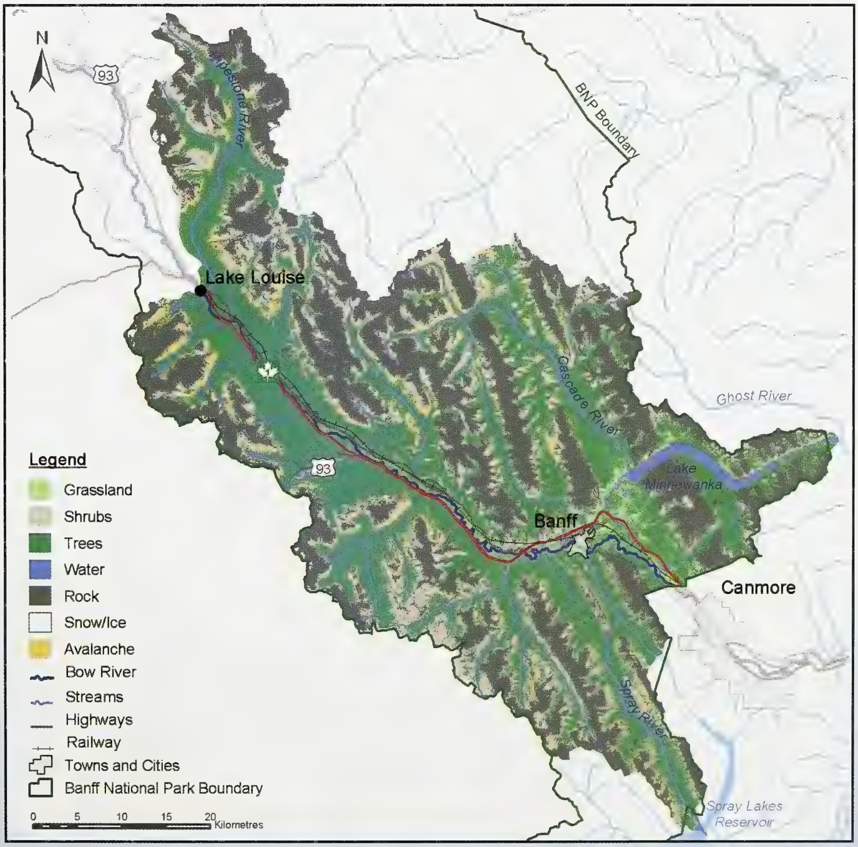
While limits have been placed on the development and expansion of both these communities, tourism and the number of recreational visitors are expected to continue to grow. In 2003, almost 4.7 million people visited BNP.[22] Use of the national transportation network within BNP is much higher, with an additional 4 million people passing through the park annually.[178 183] Most tourists visit the communities of Lake Louise and Banff and use only the frontcountry near the TCH.[183] In 2000, daily visitors to Lake Louise and the Town of Banff during the peak summer months of July and August exceeded 21,000[142] and 46,000[231] people, respectively.

There are two hydroelectric facilities located on tributaries to this reach (Table 2.4, page 29). Their operations result in substantial changes in flow to the Spray and Cascade rivers, and to a lesser extent, to the Bow River mainstem. These operations influence not only the timing and magnitude of streamflows, but also water quality and ecosystem characteristics, discussed in the sections below. The CPR and TCH have altered the alluvial fans of many tributaries to the Bow River, as well as the functioning of the river's floodplain.

No major water withdrawals are licensed for this reach. Local municipal water supplies come from groundwater sources, rather than the mainstem of the Bow River. Discharges to the Bow River from municipal, industrial and recreational users are relatively low and have little influence on water quantity.

Water quality and aquatic communities, however, are negatively impacted by wastewater discharges from Lake Louise and Banff. Increased nutrient loading has altered the aquatic ecosystem downstream of these communities.

Figure 4.2 Land use of Reach 2[39 45 254]



4.2 Hydrology

Figure 4.3 shows the average natural discharge of the *Bow River below Cascade River Confluence*. There is no station at this site, but these flows have been calculated as the sum of the flows at *Bow River at Banff*, *Spray River at Banff* and *Cascade River near Banff* (Water Survey of Canada Stations AB05BB001, AB05BC001 and AB05BD002, respectively) (Figure 4.4, page 61). Upstream of Banff, the recorded and natural flows of the river within Reach 2 are essentially the same, since no significant allocation for diversion or water storage takes place. At the *Bow River below Cascade River Confluence*, however, the natural streamflows of Reach 2 are altered by the operation of the Cascade and Spray Lakes hydroelectric plants.

On average, natural flows below the Cascade River Confluence peak in mid-June at around 200 cubic metres per second (m^3/s). The natural baseflows, consisting primarily of groundwater, occur from November to April and average around 15 m^3/s. Relative to the large annual fluctuations in the snowpack, the contribution of glacial melt remains relatively constant. As a result, the importance of glacial melt to streamflows increases in low flow years. However, the continued retreat of glaciers in the headwaters of the Bow River Basin could result in substantial impacts on summer flows of the Bow River in Reach 2(see Chapter 2).[61 138]

Upstream of Banff, flows of the Bow River are generally unimpacted by the relatively small water withdrawals for tourism operations, golf courses and recreational facilities. These withdrawals have no measurable impact on the flow regime, water quality or habitat for riparian vegetation and aquatic animals upstream of Banff.

Both Lake Louise and Banff draw their municipal water supply from local groundwater wells and not directly from the Bow River. The wells for Lake Louise were designed for a population of 5,000 and can supply 2.6 million litres per day (L/day).[179]

In 1999, Banff withdrew over 8 million L/day from the Banff aquifer. By 2020, this use is projected to increase to 11.5 million L/day.[233] Hotels use the majority of water in Banff and Lake Louise. During the year, water use is lowest in the winter and highest during the peak summer tourist season. Both communities have implemented water conservation programs, including water meters.[179]

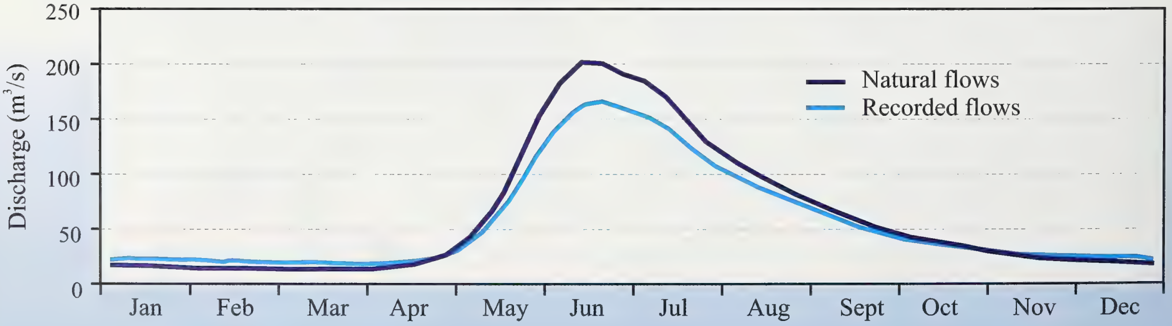
Both Lake Louise and Banff discharge stormwater and treated wastewater to the Bow River. While these discharges have relatively small impacts on water flows, they do impact water quality and aquatic resources within Reach 2 (see Section 4.3). The natural flows of the Bow River help assimilate these wastewaters, but cannot fully alleviate the impacts on the aquatic environment.

How do Hydroelectric Dams Affect Hydrology?

Both the hydroelectric plants located in Reach 2 are situated on tributaries of the Bow River. The Spray hydroelectric generation system is located at the headwaters of the Spray River and includes the Three Sisters, Rundle and Spray hydroelectric plants. The Spray River naturally flows into the Bow River in Reach 2. However, Canyon Dam restricts the flows from the reservoir into the Spray River. The majority of flows are diverted north, through the Three Sisters Dam and via a canal, toward Canmore and the Bow River within Reach 3. The remaining flow in the Spray River is highly regulated and much lower than historic flows.

The Cascade hydroelectric generation system was created through the damming of the Cascade River and Lake Minnewanka, increasing the size of the lake. In addition, a portion of the North Ghost River is diverted to Lake Minnewanka. As a result, some flows from the North Ghost River now enter the Bow River in Reach 2, rather than Reach 3 via the Ghost River tributary. Flows from Lake Minnewanka are released through a

Figure 4.3 Discharge of the Bow River below Cascade River Confluence (1971-2001)[29]



dam at Two Jack Lake, through a portal within the dam into Cascade Creek, and through the Cascade generating station, which releases into a spillway that enters the lower portion of the Cascade River.

These hydroelectric dams have resulted in substantial changes to the natural flow regime of the Spray and Cascade rivers. The annual fluctuations in water levels of Lake Minnewanka and the Spray Lakes expose their shorelines, increase erosion and impact the aquatic communities.

Figure 4.3 shows the average recorded flows and modified flow regime for the *Bow River below Cascade River Confluence*. This pattern of storage and release results in a dampening of the seasonal variation of the river. The average recorded spring discharge peak is lower at around 165 m^3/s, while baseflows have increased to average around 20 m^3/s.

Downstream of the Cascade River, the mainstem of the Bow River also exhibits large daily fluctuations in flow due to the variable water releases from the dams. When the Cascade Plant is in operation, daily discharge of the Bow River can vary substantially. At full capacity, during some winter mornings and evenings, the plant increases the discharge of the river by about 30 m^3/s, three times as high as the natural baseflows.[104] Changes to the flow regimes of the Spray, Cascade and Bow rivers also impact water quality and habitat for riparian vegetation and aquatic animals, as discussed in Sections 4.4 and 4.5.

How do Linear Developments Affect Hydrology?

The construction and operation of the CPR and TCH have impacted natural water flows and hydrologic processes throughout the Bow Valley. One example is the alteration to alluvial fan processes. An alluvial fan is a part of a river's floodplain. It is a low, conical or fan-shaped accumulation of gravels and other sediments deposited by a stream, especially at the point where the stream channel widens and the water velocity slows. Alluvial fans are found at the base of many tributaries to the Bow River throughout Reach 2.

The channel alterations and armouring that resulted from the construction of the TCH and CPR have impacted 55 alluvial fans throughout the Bow Valley and has impeded the natural deposition and constant shifting of gravels.[96] Erosion at the headwaters (and along the stream banks) occurs as it always has, but depositional processes on the fans have been disrupted. Debris flows are prevented from being deposited on the alluvial fans and from contributing to the natural debris loading of the Bow River.

The TCH and CPR have also had substantial impacts on flows of the mainstem of the Bow River. Bridges, culverts and development along its floodplain impinge on its ecosystem functions. In particular, the national transportation corridor has impacted the Vermilion Wetlands. The wetlands are found within the northern floodplain of the Bow River and are fed primarily by groundwater.[210]

The drainage patterns of the Vermilion Wetlands and their connection to the Bow River have changed substantially since historic times.[208] The CPR railway now acts as a berm and partially stabilizes water levels in the wetlands. The TCH, railway, culverts, artificial channels, and beaver dam management have all altered the natural flow dynamics of the wetlands. Over the last decade, the CPR has made several changes to its railway line and culvert system, helping to restore more natural water flows to the Vermilion Wetlands and stabilizing CPR tracks in the area.[181 186]

Bow River in Banff National Park – J.Rouse

4.3 Water Quality

Water quality in this section of the Bow River is measured by Environment Canada at one site just downstream of the eastern BNP boundary. The site, *Bow River above Canmore* (Site 00AL05BE0013) is located approximately 3 km downstream of the BNP boundary (Figure 4.4, page 61). Compared to downstream reaches, water in this reach is considered to be of high quality. However, several point and non-point sources of pollution have impacted water quality.[120]

The biggest sources of pollutants and changes to water quality in this reach are the municipal effluents (stormwater and treated wastewater) from the communities of Lake Louise and Banff.[207] While recent upgrades to the WWTPs have greatly improved the quality of their effluent, these wastewater effluents contribute organic material, sediment, bacteria, and nutrients to the Bow River.

Other influences on the water quality of the Bow River in this reach include runoff from roadways, golf courses and historically contaminated sites (such as coal mines), as well as the septic systems that service frontcountry campgrounds. Several hazardous waste sites are located along the corridor of the Bow River Valley, and may be associated in close proximity to the Bow River.[179] These non-point source influences are difficult to quantify and no specific information exists regarding their impact on water quality on Reach 2.

Reach 2 of the Bow River is generally cold and clear. While spring runoff increases the suspended solids concentrations of the water, the Bow River generally contains very low sediment levels. Its water is well-oxygenated for most of the year, due to turbulent, fast flows. The lowest dissolved oxygen concentrations are found during the summer months, when water temperatures are higher. These lower values are temperature-related and are not expected to pose any threat to aquatic life in the river. Wastewater discharges from the Lake Louise or Banff WWTPs have not affected dissolved oxygen concentrations in the Bow River.[55 109 120]

The water within this reach is considered moderately hard and the pH is slightly alkaline. Ion concentrations in the water increase during the winter, when groundwater supplies most of the streamflow. Groundwater tends to be more highly mineralized than surface waters that are derived from snowmelt. The Spray and Cascade rivers are more highly mineralized and contribute additional ions to the mainstem of the Bow River.[249] Increases in sodium, chloride and potassium from Reach 1 to Reach 2 may be due to discharges from the WWTPs or road salting practices along the TCH and within the communities of Lake Louise and Banff (see Chapter 3).[55 109 120]

Reach 2 of the Bow River is naturally oligotrophic and low in nutrients like phosphorus and nitrogen. Lower concentrations of dissolved nutrients are found in the summer compared to winter, likely due to increased dilution from higher water levels in the spring/summer peak flows, as well as increased biological uptake of the nutrients.

The natural form of phosphorus in the Bow River is primarily particulate and is not readily available for use by aquatic communities. WWTPs, however, discharge higher concentrations of phosphorus into the river, and about half of this is in dissolved form. This form is bio-

Bow River at Banff – M. Bennett

available and can stimulate aquatic plant growth (see Section 4.4). Wastewater effluents also increase nitrogen and ammonia concentrations in the Bow River downstream of the treatment plants.[55 109 120]

Both the Banff and Lake Louise WWTPs have received recent major upgrades. Banff was upgraded in 1989 and 2003, while Lake Louise was upgraded in 1998 and 2003. Upgrades to both WWTPs include tertiary treatment for phosphorus removal and ultraviolet light irradiation to disinfect bacteria. Upgrades to the Lake Louise WWTP have also increased its capacity to deal with projected growth, from the nearby ski hill, as well as the community.[179]

While phosphorus loading has substantially decreased since the 2003 upgrades, it may take some time before phosphorus concentrations in the Bow River drop to historic concentrations. Phosphorus binds strongly to particles and is readily stored in stream sediments, from which it can mobilize to the water column. The assimilative capacity of the Bow River during the winter season is of particular concern, when the flows of the river are naturally at their lowest.

Bacterial concentrations are naturally very low in Reach 2 of the Bow River. The presence of fecal coliforms indicates contamination by wildlife or human wastes. As a result, adequate treatment is necessary to avoid the potential for severe gastrointestinal illness. Following the upgrades to both the Banff and Lake Louise WWTPs, bacterial counts in the river have substantially improved, such that these WWTPs have no significant impact on fecal coliform concentrations in the Bow River.[203]

Metals concentrations are generally very low within Reach 2. Total aluminium, copper and lead occasionally exceeded water quality guidelines for the protection of aquatic life. In general, however, these increases were transient and considered to be within the natural range. Because the majority of these metals are in the particulate form, they are less bio-available, and no impacts on the health of aquatic organisms are expected. Pesticides were not included in Environment Canada's monitoring program above Canmore, due to the lack of agricultural activity.[120]

What's going on in Banff?

The Town of Banff is engaged in a number of activities to actively manage their impact on the Bow River. Major upgrades to the WWTP in 2003 included bio-solids composting, reduced chemical use and improved removal of sediments, nutrients and micro-organisms. The goal is to improve effluent quality for total phosphorus, ammonia nitrogen and fecal coliforms beyond provincial regulations and toward leadership targets set for the national parks. In particular, the WWTP upgrades have resulted in a 90% reduction in phosphorus loading to the Bow River.

The Town of Banff is in the final stages of preparing a Drainage Master Plan to safeguard the community from potential flooding. Identifying best management practices for addressing stormwater quality issues is a key component of this study. The final stage of an environmental management system for all municipal activities is being developed. This will allow the town to address environmental issues before they become significant.

A community protocol was established in 2002 to engage volunteers in monthly water quality sampling. The monitoring is undertaken in partnership with the Biosphere Institute of the Bow Valley and the Canadian Community Monitoring Network and aims to measure Banff's impact on the Bow River. Four monitoring stations are located upstream and downstream of the town and the WWTP.

Health Canada's and Environment Canada's Community Animation Program fund has allowed the Town of Banff to deliver a pesticide education program. The program is entitled "Lawn 'n' Order", and it seeks to educate landscapers, property managers and residents about the environmental impacts of using pesticides. By promoting alternatives to cosmetic pesticides, the number of pesticides that reach surface and groundwater supplies may be reduced.

4.4 Ecosystems

Terrestrial Habitat

The terrain within the watershed of Reach 2 varies from steep mountain peaks to the broad Bow River Valley (Table 4.1). The alpine natural region is found on the peaks of the Rocky Mountains; the sub-alpine natural region occurs at lower elevations on the mountains and the montane region lies along the valleys (Figure 4.4).[19] The vegetation and animals that are characteristic of the alpine and sub-alpine regions are described in Chapter 3.

The western limits of the montane region begin west of Castle Junction and extend east. Montane ecosystems are considered the most biologically diverse areas in BNP due to their relatively low elevations, moderate climate, and proximity to water bodies.[2] The montane region is dominated by stands of lodgepole pine intermixed with Douglas fir and white spruce. Douglas fir stands are considered special resources in BNP because of their limited distribution.[1]

Steep slopes with rapid drainage give way to limber pine, while moist sites along creeks and rivers are dominated by balsam poplar and willow stands. Trembling aspen stands, fescue and grasslands occur in the warmest, driest areas of the Bow Valley.[227] Shrub species include buffaloberry, bearberry and juniper.[19]

The montane region provides the most important, though limited wildlife habitat in the Bow Valley. It supports a variety of large mammals, including grizzly bears, black bears, wolves, cougar, elk, and deer. Other animals include coyote, weasel, mink, beaver, muskrat, Columbian ground squirrel, and red squirrel. Virtually the entire landbase is considered to be environmentally significant – internationally, nationally or regionally.[232]

Table 4.1 Size and extent of Reach 2 features[23 39 40 45 195]

Natural Feature	Area (km^2)	Extent of Reach (%)
Icefields	25	0.88
Alpine sub-region	1,357	47.77
Sub-alpine sub-region	1,090	38.38
Montane sub-region	318	11.2
Lakes	36	1.25
Reservoirs	1	0.03
Wetlands	8	0.27
Rivers	6	0.21
Total	**2,841**	**100.00**

The Bow Valley is considered an internationally significant wildlife travel and migration corridor. It has high wildlife values for birds, large carnivores, small mammals, ungulates, reptiles and amphibians.[232] Major wildlife corridors include the Fairview, Bow River and Whitehorn corridors near Lake Louise [179] and the Cascade corridor near Banff.[50] The Hillsdale, Johnston Canyon and Sawback Ranges are considered significant for their elk, deer, mountain goat, bighorn sheep, and moose habitat. The Middle Spray/Bryant Creek area has been identified as a core reproductive area for grizzlies. The Lake Louise area provides critical elk, bighorn sheep and mountain goat habitat.[232]

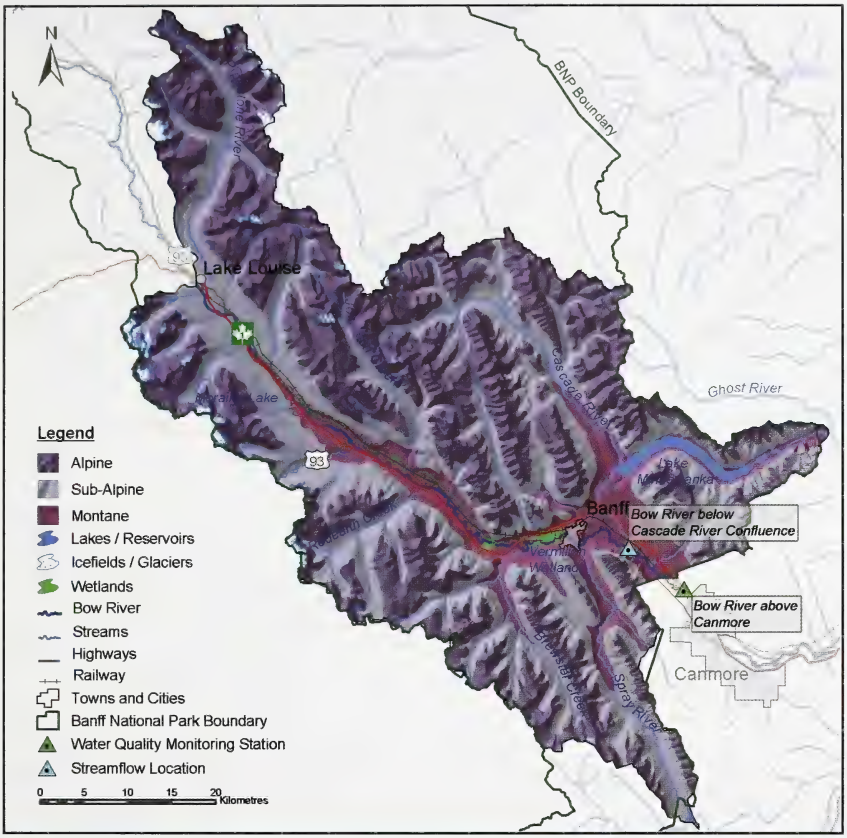
Human activities have had significant impacts on the terrestrial landscape and wildlife species within BNP. Approximately 118.8 km^2 (4.2%) of the watershed of Reach 2 has been cleared for linear developments (including the TCH and CPR), hydroelectric facilities, tourism and recreational activities, and for the communities of Lake Louise and Banff. Landscape fragmentation, loss of habitat connectivity, blockage of wildlife movement across the Bow Valley, altered predator-prey relationships, introductions of non-native plants, and loss of montane habitat due to development and fire suppression are current concerns.[50]

In the Bow Valley, vegetation is influenced primarily by fire, avalanche and flood disturbances and herbivory of large mammals, such as elk. Human activities have impacted these influences and added others.[2] Historically, First Nations people started fires throughout the Bow Valley to encourage new growth.[50] Since 1880, however, fire suppression has led to aging forests and changes to wildlife habitat. The absence of fire has led to a decrease in open grasslands, shrublands, deciduous forests, and young coniferous forests, and an increase in older coniferous forests.

Without fire, lodgepole pine forests do not regenerate and are eventually replaced by fir and spruce forests.[179] Fire suppression has also reduced aspen regeneration. Attempts to replicate natural fires include prescribed burns along priority areas. By 2003, almost 10,000 ha of forest in BNP had been burned,[180] primarily in the Fairholme Range around Lake Minnewanka. Prescribed burns and selective logging are also used to manage infestations of mountain pine beetle in the park.[184] In turn, these changes have lead to modifications of wildlife habitat.

The CPR, TCH, vehicle traffic, parking congestion, and urban and tourist developments pose obstacles to wildlife movements throughout the Bow Valley. Human activity has negatively impacted prime grizzly bear

Figure 4.4 Natural sub-regions and measuring locations of Reach 2 [23 39 40 45 195]

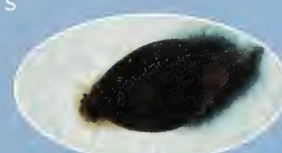


habitat in the Lake Louise ski area, particularly during the summer months.[157] About 90% of grizzly bear deaths in BNP occur within 500 m of human facilities.[50] Black bear mortality is also relatively high due to human interaction and highway conflicts. Since recolonizing the Bow Valley in 1985, the wolf population has shown an overall increase, though numbers are still small. Increases in cougar numbers were observed during the mid-1990s, but elk relocation programs and increased wolf populations have kept park cougar numbers relatively low.[181]

The number of elk in the Bow Valley has declined since 1997 due to the elk relocation program and increased predation by wolves and cougars. The decrease in population and density of elk is a positive result of efforts to restore historic elk distribution patterns to the montane region. Moose populations in the park declined in the 1960s and 1970s

The Banff Springs Snail

The Banff Springs snail is perhaps the most "at risk" species in BNP, more so than the grizzly bear or other, more familiar, species. Its formal status varies from "may be at risk" (Alberta status), to "endangered" (COSEWIC status) to "acutely endangered" (Banff-Bow Valley Study). This tiny snail, about the size of a lemon seed, is endemic to thermal springs in BNP and is found in water ranging in temperature between 30 and 36°C. It is at risk because of its extremely limited range. While previous studies had shown it was extirpated from nearly half its historic range, recent reintroduction efforts into the upper Middle Springs have been successful. It is currently found in six hot springs on Sulphur Mountain, having been extirpated from two others. Historically, the cool spring in the Vermillion Wetlands also provided habitat for this snail, but since the CPR altered the natural flows, this population has been eliminated. The snail population fluctuates dramatically, and is at its lowest when spring runoff cools the springs. Small disturbances to the springs, such as people bathing, create waves that disturb the algae mats where the snails feed and lay their eggs. Chemicals, deodorants, and insect repellents on people's skin also harm snails and their habitat. As a result, the Sulphur Mountain Wildlife Corridor and the Cave and Basin National Historic Site are now closed to visitors. Because vandalism and disturbance of these hot springs are major threats to the continued existence of the snail, fines are in place for the illegal use of the springs. It is hoped that these programs will protect the existing snail populations.[154 185]



and have remained low since. Reasons for the decline include a combination of highway and railway mortality, habitat and food competition from elk, liver-fluke transmission from elk, fire suppression, and predation from wolves.[181]

The implementation of measures to improve wildlife movement and predator-prey relationships and to reduce human impacts is ongoing. It is hoped that the next phase of TCH twinning and additional wildlife crossing structures planned from Castle Junction to the western boundary of BNP will further reduce conflicts of vehicles and wildlife. Constructed first during the mid 1980s, and again in the late 1990s, innovative wildlife crossing structures have partially restored wildlife movement within BNP. Use of the constructed corridors by wildlife has been found to increase over time. Deer and elk immediately started using the structures, while carnivores like bears, cougars and wolves have taken several years to habituate to them.[181] Concerns remain regarding reductions to reproductive rates and genetic diversity from the altered wildlife movement patterns.

Riparian and Wetland Habitat

Along much of its length within Reach 2, the Bow River has a wide, meandering, rocky floodplain that is well vegetated with shrubs.[179] Islands, side and mid-channel gravel bars, and meander scars can be seen along the main channel. A mixture of dense and open stands of white spruce, poplar and willow dominate the riparian areas.[19]

The riparian area of this reach has been impacted by human activities. The CPR and TCH compromise the functions of its natural floodplain and the alluvial fans of many of its tributaries. The riparian health of the Spray and Cascade rivers and the lower section of the Bow River in this reach is impacted through changes to streamflows from hydroelectric facilities. Non-native and invasive plants found in this reach include Canada thistle, common toadflax, tall buttercup, and perennial sow-thistle.

Between Lake Louise and Banff, the Bow River supports high densities of breeding harlequin ducks. These ducks require fast-flowing streams, with healthy benthic invertebrate populations, surrounded by undisturbed shrubs and mature forests.[183 214] In the spring, the section of the Bow River between Lake Louise and Castle Junction has one of the highest concentrations of these ducks in western North America.[179] They gather along the Bow River in April to mid-May, before dispersing to nest in small mountain streams during the summer. The harlequin is the only duck in North America that migrates from the sea to nest along mountain streams. In Alberta, it is listed as "sensitive" (see Chapter 2).[44]

Wetlands are scattered throughout the watershed of Reach 2. The largest wetland in BNP is the Vermilion Wetlands Complex, which is a mosaic of lakes, fenlands, shrublands, sedge meadows and mixed forests, located just west of the Town of Banff.[186] These wetlands are considered internationally significant for the diversity of plants, mammals, amphibians, and resident and migratory birds they support.[232]

The area is also vital to migratory birds, which commonly include the cinnamon teal, red-necked grebe, and merganser. From May to mid July, an abundance of waterfowl and small songbirds breed in the wetlands. Because it is one of the few areas of open water in the winter, it is also important to resident birds within the Bow Valley.[232]

Harlequin Ducks – A. MacKeigan

Other wetlands are found along the lower reaches of the Pipestone River and toward Corral Creek.[50] Migratory birds use the open waters of the Bow River, as well as several shallow lakes and ponds, en route to nesting grounds. Waterfowl overwinter in open water areas such as the Cave and Basin Marsh and the Bow River downstream of Banff. Significant habitat for the Columbia spotted frog and long-toed salamander is also provided in several wetlands and ponds.[232] The long-toed salamander is found in shallow breeding ponds that are generally free of fish and not necessarily permanent. Historical fish stocking has reduced salamander numbers in several areas.[208] The Columbia spotted frog and long-toed salamander are both listed as "sensitive" in Alberta.[44]

Unique aquatic ecosystems include the Sulphur Mountain thermal springs. These thermal springs are fragile, small-scale ecosystems created by and dependent on geothermal activity. The hot mineral springs begin as groundwater that seeps into the mountain. Three kilometres within the earth, it is heated, mineralized and pressurized, and then percolates back to the surface along the Sulphur Mountain thrust fault, emerging in several springs. Flows and temperatures vary seasonally and annually, based on precipitation. On occasion, for natural reasons, some of the springs run dry.

Cool freshwater springs are also found along the western edge of the Vermilion Wetlands,[181] keeping the third lake relatively ice-free during the winter. Other cool water springs include one on the Cave and Basin Road, west of the townsite.

Aquatic Habitat

Aquatic communities in Reach 2 are limited by naturally cold waters and lack of shelter within the Bow River. Natural nutrient concentrations in the water are low, but the nutrient loading downstream of Lake Louise and Banff has increased the productivity of the system.[58] Bow Falls, located on the Bow River just downstream of Banff, presents a natural barrier to upstream fish movement. Some high-elevation tributaries are devoid of fish, due to the steep gradient and presence of impassable waterfalls. Despite these limitations to habitat and productivity, Reach 2 supports a wide variety of native and introduced cold-water fish species.

The fish populations in the upper Bow River have changed substantially over time, with native species being replaced by non-native species. Species native to the Bow River in Reach 2 include bull, lake and westslope cutthroat trout, mountain whitefish, white and longnose suckers, longnose dace, brook stickleback, burbot, and lake chub.[50] Of the 20 species now in the Bow Valley, 10 are introduced. In order to attract anglers, stocking of non-native fish began at least as early as 1904 and included brown, brook, rainbow, and Yellowstone cutthroat trout.[208] Competition, hybridization, overfishing, and habitat destruction have all contributed to the decline of native species in Reach 2.[164]

Fisheries investigations in the Bow River and its tributaries near Banff suggest that the fish community is currently dominated by brook trout, mountain whitefish, longnose suckers, and white suckers; it was

The Banff Longnose Dace

The Banff longnose dace is the only endemic fish species within BNP. This smaller sub-species of the longnose dace was confined to a marsh draining the Cave and Basin hot springs. It has been listed as extinct since 1986, its population having been eliminated by a combination of hybridization, habitat alterations and non-native fish introductions. Due to interbreeding with longnose dace from the Bow River, chlorinated water releases from the developed hot springs, beaver dam removal, and competition and predation from introduced tropical fish, this unique fish is no longer found in the marsh.[208] Mosquitofish are now the most abundant species in the Cave and Basin hot springs and marsh area, and may be present in the Vermilion Wetlands. They were introduced in 1924 to control mosquitoes around the hot springs bathhouse. The sailfin molly and African jewelfish were also introduced to the hot springs, likely from dumped aquariums.[illegible] There is still debate whether the Banff longnose dace are a distinct sub-species and not simply an adaptation to the warmer water.[172] In 2002, dace specimens were captured from the Cave and Basin Marsh. They are currently being compared with museum specimens to confirm their status.[illegible] The history of this species highlights many of the pressures on native fish within BNP as well as complex taxonomic issues.

historically dominated by mountain whitefish and bull and westslope cutthroat trout.[164] Cutthroat trout have essentially been eliminated in the mainstem of the Bow River in Reach 2,[163] due in part to hybridization with introduced rainbow and Yellowstone cutthroat trout, and below Bow Falls, to competition by brown trout.[208] A few lakes and the upper tributaries of the Bow, Spray and Cascade rivers contain some native cutthroat trout, however, few pure stocks remain in the Bow River drainage.[163]

The abundance and distribution of the bull trout population within Reach 2 have also declined since historic times, due to overexploitation, competition and hybridization with introduced brook trout.[165] Brook trout can now be found in 100% of the bull trout's historical distribution.[208] There are still bull trout in several lakes and tributaries, including Forty Mile and Silverton creeks, and the Pipestone and upper Cascade rivers,[105 165] however, they are now rare in the mainstem of the Bow River below Bow Falls.[105] The bull trout is listed as "sensitive" within Alberta, and all bull trout caught must be released. While the status of the cutthroat trout is listed as "secure" within Alberta,[19] all cutthroat trout caught within BNP must be released (see Chapter 5).

Cumulative pressures on the native fish species within Reach 2 also include physical barriers posed by culverts and dams, which restrict migration and access to spawning areas. The large hourly flow fluctuations downstream of the Spray and Cascade hydroelectric plants create habitat instability. Large annual fluctuations in the water level of Lake Minnewanka adversely affect the aquatic environment around the margins of the lake, limiting plant growth, invertebrate communities and the fish populations they support.[207]

Perhaps the greatest water quality influence on aquatic systems in Reach 2 is nutrient enrichment from wastewater effluents, which has increased the productivity of the Bow River. Like most mountain rivers, the Bow River naturally contains low nutrient concentrations, particularly phosphorus, resulting in an oligotrophic (low productivity) system. The nutrients released by the Lake Louise and Banff WWTPs have increased algae growth downstream of these communities.[208]

Due to increases in the algal food base, increased numbers of benthic invertebrates are found downstream of the Lake Louise and Banff WWTPs.[58 166] The benthic invertebrate communities now contain a higher proportion of species more tolerant of pollution, such as midge fly larvae and worms.[58] Several species of benthic invertebrates unique to the Bow River and lakes within BNP have been identified, including caddisfly and stonefly species.[208] These unique species may be at risk from cumulative changes to water quality and aquatic habitats. Recent upgrades to the Lake Louise and Banff WWTPs are expected to reverse or reduce some of these changes to the aquatic environment.

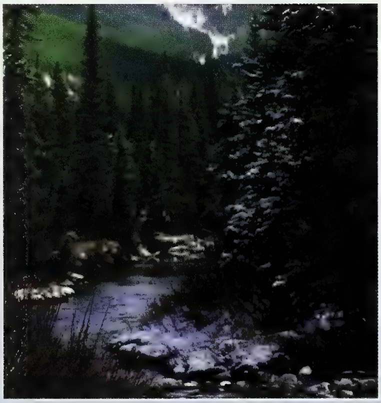
4.5 Tributaries

Pipestone River

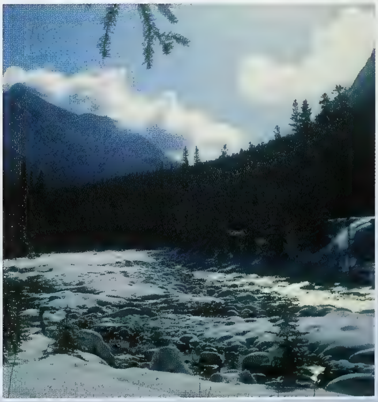
The Pipestone River is found at the upper boundary of this reach, and enters the Bow River from the north, at the community of Lake Louise. The Pipestone River originates near Devon Mountain and Pipestone Pass and flows southeast for approximately 35 km to the Bow River. The river's gradient is relatively low in the central portion and increases through the canyon section at the lower end of the river. Urban development along the lowest section of the Pipestone River as it passes through Lake Louise has decreased the extent of the riparian zone and led to the proliferation of non-native weed species.[179]

Mountain whitefish and brook, bull and cutthroat trout are found in the Pipestone River.[166] A ski resort withdraws water from the lower section of the river for snowmaking and domestic purposes. Decreases in

Lake Minewanka – BRBC



Creek and Willows – A.MacKeigan



Spray River – H.Kariel

streamflows are linked to these water withdrawals,[181] and may have led to deteriorations in aquatic habitat. A plan by a ski hill operator to use groundwater to supplement its snowmaking is under review.[179] The removal of infrastructure within the river has been initiated and restoration opportunities for riparian areas have been identified.[181] Riparian restoration will be particularly important for the Harlequin duck, which is known to nest along the Pipestone River.[214]

Spray River

The Spray River is located at the southeast boundary of the reach and flows into the Bow River just downstream of the Town of Banff and Bow Falls. The flows and aquatic habitat of the Spray River have been substantially altered by hydroelectric development. The inundated area of the Spray Lakes has been extended almost 10 times, creating a reservoir 23 km long.[207] The Canyon Dam blocks the natural outlet of the lakes, reducing downstream flows of the Spray River. Much of the flow is now diverted toward Canmore via a canal. Tributaries to the Spray River include Bryant, Turbulent and Smuts creeks in the upper reaches, and Goat Creek in a lower reach.[208]

Historically, the river and lakes supported populations of bull and cutthroat trout and included important spawning habitat.[207] Seasonal migration from the lakes historically supported the fish populations within the lower Spray River. The dam now presents a barrier to fish movement. The combination of reduced flows and habitat alterations has substantially reduced the fish populations in the river downstream of the dam. Introductions of brook and rainbow trout have also had negative impacts on the native cutthroat and bull trout populations.

During the summer, the cold temperature of the water released from the dam into the lower Spray River has likely reduced benthic invertebrate numbers, further reducing the productivity of the river for fish.[169] The severe reduction in overall flows and seasonal variation has also resulted in the loss of riparian vegetation along the lower Spray River. Cutthroat and bull trout are still found in the headwaters of the Spray River above the reservoir, but have been reduced in numbers and face competition from introduced Dolly Varden.[163 165]

In 1950, lake trout were stocked in the Spray Reservoir, as it was determined that the reservoir was too deep for cutthroat trout. Monitoring indicates that by 1977, both bull and cutthroat trout had virtually disappeared from the reservoir. The population of the reservoir is now dominated by mountain whitefish and lake trout, with smaller populations of longnose sucker and introduced cisco.[208]

Cascade River

The Cascade River enters the Bow River from the north approximately 5 km upstream of the eastern BNP boundary. It flows south through Stewart Canyon and into the western arm of Lake Minnewanka. Upstream of Lake Minnewanka, the upper Cascade River flows relatively unimpeded. The section of the channel downstream of the lake to its confluence with the Bow River has been greatly altered over the past century. Various human activities, including coal mining, gravel extraction and dam construction have impacted the flows and aquatic habitat of the lower Cascade River.

The first hydroelectric dam on the river was constructed in 1912, creating a small reservoir at the present Lake Minnewanka location. Subsequently, gravel extraction at the Cascade Gravel Pit and Cascade Ponds for construction of the TCH required the diversion of the river channel around these excavations. Finally, dam construction in 1942 resulted in the diversion of 8.3 km of the river downstream of Lake Minnewanka.[208] This dam raised the level of Lake Minnewanka by 30 m and flooded the tiny village of Minnewanka Landing.

The Cascade hydroelectric plant now controls water flows into the lower Cascade River. Historic streamflows in this channel averaged 8 m^3/s; these have decreased to an intermittent release of 0.1 m^3/s during the summer months.[207] Releases from the Cascade hydroelectric facility cause flows in the lowest section of the river to fluctuate from zero to 40 m^3/s up to several times a day, according to electricity demand.[230]

Both bull and cutthroat trout can be found in the upper reaches of the Cascade River.[105 163] However, alterations to the natural stream channel and flows of the lower Cascade River have significantly impacted aquatic habitat. The reduction and/or elimination of flows throughout the lower channel have reduced both the floodplain and the extent of the riparian vegetation, which is being replaced by terrestrial plant species.[207] Fish habitat in the Cascade River between the dam and the Cascade Ponds has been greatly reduced, but still supports a resident population of introduced brook trout.[208] Downstream of the Cascade Ponds, fish habitat has essentially been eliminated.[230]

TransAlta Utilities has modified the operation of the Cascade plant in order to compensate for some of the losses in aquatic habitat. Flows from the dam outlet to Cascade Creek have been increased to sustain the brook trout population now found in this channel. In addition, habitat for long-toed salamanders, created by water leaking from a buried penstock, has been protected. Special valves were installed on the penstock to maintain water flows to the salamander habitat.[104]

4.6 Where are we Headed?

The consumptive use of surface waters is not a major concern in this reach, however flows have been altered from historic conditions, with resultant changes to alluvial fans, channel maintenance and riparian habitat. The assimilative capacity of the river continues to be a concern. Improvements to the effluent quality released by the upgraded Banff and Lake Louise WWTPs may be somewhat offset by future increases in wastewater volumes.

While residential and commercial caps have been established at Lake Louise and Banff, expected increases in tourism and existing recreational facilities present challenges for the future. These continuing pressures on the watershed, streamflows, water quality, and aquatic resources within Reach 2 necessitate the collection of comprehensive information on which to base predictions, measure responses and facilitate management decisions.

Water quantity is measured within this reach at one station; water quality is measured just downstream of the eastern boundary of BNP. These monitoring programs provide an excellent information base on the status of water quantity and quality in this reach. In addition, Lake Louise and Banff both monitor the water quality of the Bow River downstream of their communities in order to capture their respective impacts on the river.

As the upgraded WWTPs discharge fewer nutrients to the Bow River, the potential transition of the aquatic system back to its historic oligotrophic status should be documented. Local groundwater resources require more frequent monitoring in order to ensure that the aquifers are not being overly impacted by domestic use.

Continuing research on native fish, specifically bull and cutthroat trout, will help define their current status and identify where re-introductions may be possible. Aquatic systems that may be closed to fishing in the future are being studied, as is the issue of how to restore naturally fishless lakes.[181 183] While the impacts from dams in Reach 2 may not be easily mitigated, there are opportunities to address other barriers to fish movement, including channelization and culverts. The feasibility of removing the dam on Forty Mile Creek to improve habitat for its bull trout population is being investigated.[180]

The Banff-Bow Valley Study (BBVS), written in 1996, contained over 500 recommendations, many of which focused on improving the aquatic ecosystems within BNP[50]. This document developed a set of goals and was meant to provide direction for the future management and human use of the area.

Though the study has been criticized for exaggerating the significance of some issues, it is undeniable that some of Parks Canada's policies and federal laws have been inconsistently applied within BNP.[153] Recent achievements toward the goals of the BBVS include the development of the Banff National Park Management Plan, the Lake Louise Community Plan, residential community caps and upgrades to the Lake Louise and Banff WWTPs. However, the data gaps listed above represent opportunities to improve the understanding and management of the Bow River within Reach 2.

Chapter 5

Bow River near Cochrane – J.Fennell

Chapter 5

Reach 3 – Banff National Park Boundary to upstream of the Bearspaw Dam

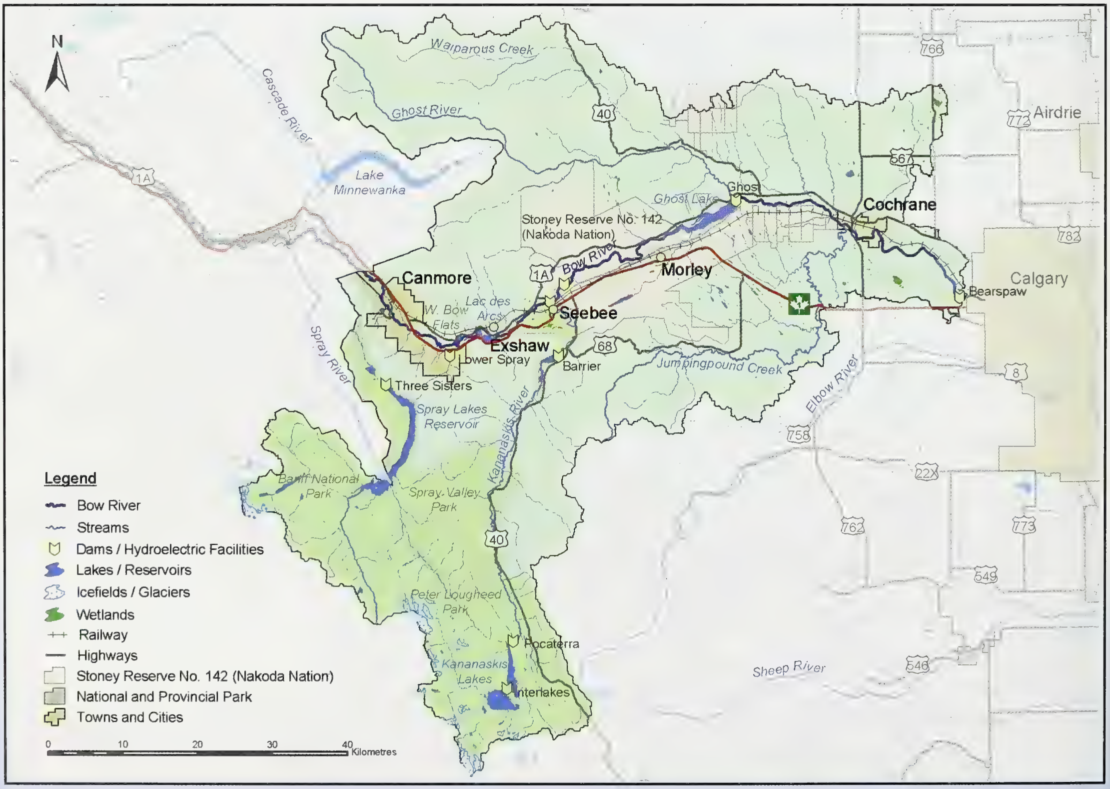
5.1 What is in this Reach?

Reach 3 begins at the eastern boundary of Banff National Park and extends to the Bearspaw Dam. Within this reach, the Bow River winds its way through the foothills onto the prairie. As it leaves Banff National Park, it enters the Municipal District of Bighorn and flows past the communities of Canmore, Exshaw, and Seebe. The river flows through Kananaskis Country before entering the Stoney Reserve No. 142 (Nakoda Nation) and passing the community of Morley. It then enters the Municipal District of Rocky View, passes Cochrane and heads toward Calgary. Reach 3 ends upstream of the Bearspaw Dam near the outskirts of Calgary (Figure 5.1). The total length of the reach is 117 kilometres (km) and it drains an area 4,453 square kilometres (km^2) in size.

Many small tributaries contribute to the flows of the river in this reach. The major tributaries are the Kananaskis and Ghost rivers, as well as water from the Spray Lakes Reservoir. The natural outflow of the Spray Lakes Reservoir is to the west, via the Spray River, which enters the Bow River just downstream of Banff in Reach 2. The upper Spray River, however, has been dammed, and the majority of the reservoir's outflow now exits north via a canal, entering the Bow River at Canmore.

The landscape changes from mountains to foothills to prairie and pine, spruce and aspen forests change gradually to grasslands. This diversity provides homes for a wide variety of large and small mammals, including elk, deer, bear, and coyote. The river valleys

Figure 5.1 Overview of Reach 3[16,39,45]



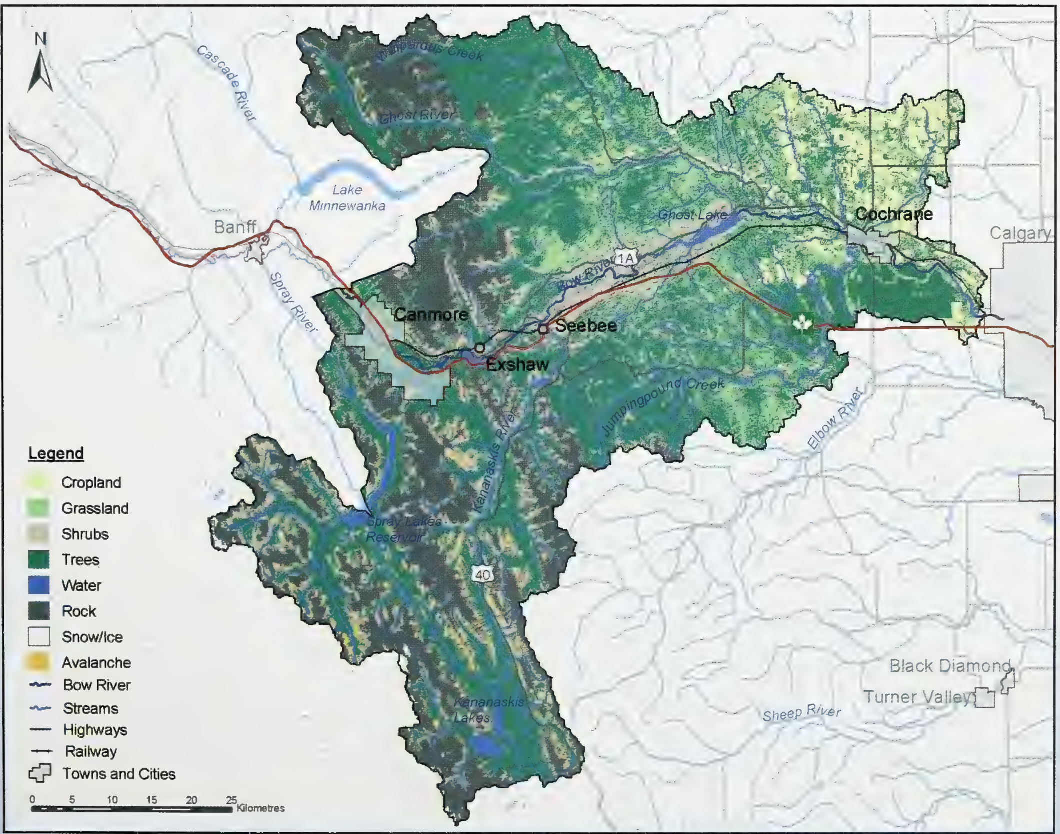
are essential wildlife movement corridors through the mountains, but human development and activities have compromised this function. Riparian areas and wetlands are also abundant and provide habitat for migratory birds. Weed species, however, have become established in the riparian zone. Native fish species within this reach include bull and westslope cutthroat trout and mountain whitefish. The trout are no longer the most common species, and their populations face continued pressure from habitat loss and historical introductions of non-native fish.

The diverse landscape is reflected in the park status given to much of the watershed, including Canmore Nordic Centre Provincial Park, Spray Valley Provincial Park, Bow Valley Wildland Park, Bow Valley Provincial Park, Peter Lougheed Provincial Park, Elbow-Sheep Wildland Park, Ghost River Wilderness Area, and Don Getty Wildland Park. About 46% of the watershed of this reach has park or protected status. Several of these parks have been created since the previous State of the Bow River report, indicating a change in land protection policy.[57] The types of human use and activities permitted within these areas vary.

The greatest human influences on the river within Reach 3 are the hydroelectric dams and diversion works, which are located on both the mainstem and tributaries of the river (Table 2.4). In addition to the three hydroelectric plants of the Spray system, six other hydroelectric generating facilities operate within Reach 3. Because the impacts of these generating facilities combine with the influences of the Cascade hydroelectric plant located upstream in Reach 2, the flows in this section of the river are highly altered from their natural pattern. Some of the hydroelectric facilities also cause substantial daily flow fluctuations in the Bow River and its tributaries. These dams influence not only the timing and magnitude of streamflows, but also water quality and the ecosystem characteristics discussed in the sections below.[123]

Harvie Heights, Canmore, Deadman's Flats, Exshaw, Morley and Cochrane are located within the watershed of Reach 3. Because these communities withdraw water from and subsequently discharge water into the Bow River system, they also influence the water quantity and quality of the river. Human population growth is likely the biggest change to occur

Figure 5.2 Land use of Reach 3[39 45 254]



over the last decade. As of 2003, about 35,000 people live in these communities and in the outlying areas.[36] Canmore alone has grown from 6,621 people in 1993 to a population of 11,458 in 2003 and is expected to reach a population of more than 15,000 by 2005 and 30,000 by 2013.[149 150]

Cochrane has also doubled since 1993, to a 2003 population of 12,074. The town's population is projected to double again by 2010.[36]

On August 31, 2004, the small community of Seebe was closed down. It had been developed by TransAlta (then Calgary Power Ltd.) in 1909 to house those working at the Kananaskis Falls and Horseshoe Falls dams. It subsequently served as a housing site for plant operations and maintenance staff. While a changing business climate resulted in TransAlta's decision to close down the town they owned, new residential development is planned on adjacent land.

Forestry, agriculture, grazing and oil and gas developments are the predominant human land uses, however, the majority of the landscape (93.1%) remains in its natural state (Figure 5.2). Urban areas and transportation infrastructure (the TransCanada Highway and Canadian Pacific Railway) are concentrated along the mainstem of the river.

Tourism and recreational use are high, particularly in the Kananaskis and Ghost drainages, and include hiking, camping, mountain biking, golf, skiing, dog-sledding, boating, fishing, kayaking, canoeing, rock climbing, and off-highway vehicle use. Given the high number of recreational opportunities, the short distance from the urban centre of Calgary, and the excellent road access within this area of the watershed, increased levels of tourism and recreational use can be expected in the future.

5.2 Hydrology

The natural flows of the Bow River in Reach 3 are illustrated in Figure 5.3, which shows the average discharge of the *Bow River below Seebe* (Water Survey of Canada Station AB05BE004) (Figure 5.5, page 76). Average natural streamflows peak in late June at about 250 cubic metres per second (m^3/s). Natural baseflows, which are mainly groundwater, occur from November to April and average slightly more than 20 m^3/s.

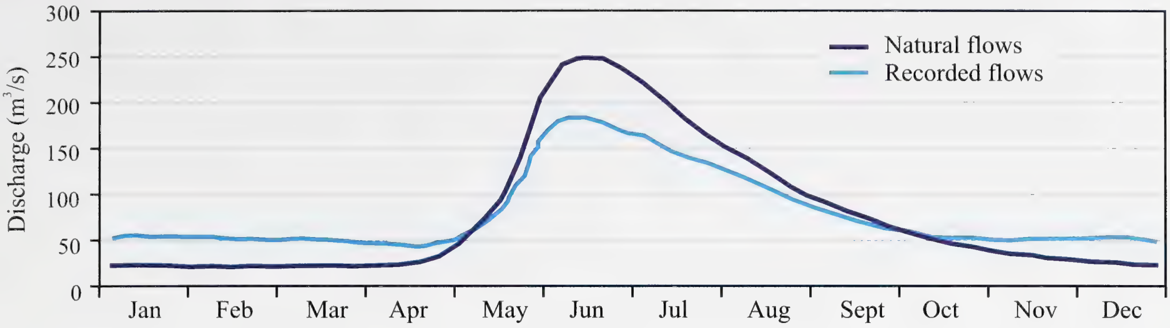
How do Hydroelectric Dams Affect Hydrology?

Changes to the natural flow regime from hydroelectric facilities are greatest in this reach. The Kananaskis Falls, Horseshoe Falls and Ghost dams are all located on the mainstem of the Bow River; the Interlakes, Pocaterra and Barrier dams are located on the Kananaskis River. The Spray System is located on the headwaters of the Spray River, and includes the Three Sisters, Rundle and Spray hydroelectric facilities. The Spray River flows into the Bow River in Reach 2, however, the Canyon Dam restricts the flows from the reservoir into the river and diverts the majority of flows north, through the Three Sisters Dam and via a canal, toward Canmore and the Bow River in Reach 3.

The flows from this canal are used for hydroelectric generation. The diversion of a portion of the North Ghost River into Lake Minnewanka forms part of the Cascade hydroelectric generation system. Some flows from the North Ghost River now enter the Bow River in Reach 2, rather than Reach 3, via the Ghost River tributary. These hydroelectric developments and diversions have resulted in substantial changes to the natural flow regime of the Bow River and its Spray, Kananaskis and Ghost river tributaries.[17]

Hydroelectric development on the Bow River

Figure 5.3 Discharge of the Bow River below Seebe (1971-2001)[29]



The average recorded flows on Figure 5.3 represent the modified flow regime for the Bow River at Seebe as the result of the operations of the Spray, Interlakes, Pocaterra and Ghost dams. Compared to natural flow data, lower spring and summer peak flows and higher fall and winter baseflows are observed in the river downstream. The average recorded spring discharge peaks around 185 m^3/s, while baseflows now average around 50 m^3/s.

Other hydroelectric facilities within Reach 3 are considered run-of-river developments and have relatively small impacts on the seasonal flows of the Bow River. Run-of-river facilities, such as the Kananaskis Falls and Horseshoe Falls dams, do not have reservoirs; water is passed through the generation plants as soon as it arrives from upstream. The small reservoir created by the Barrier Dam has only negligible storage capacity and is also considered run-of-river.[104]

In addition to seasonal changes in flows, the mainstem of the river within Reach 3 also exhibits large daily fluctuations in flow due to the variable water releases from some dams.[90] Rapid releases, termed hydro-peaking, create problems with ice cover stability and increase the possibility of winter ice jam flooding. Anglers and other recreational users of the river can be placed in some danger if water levels and flows are allowed to fluctuate over a short period of time.

These changes to the flow regime also impact water quality and habitat for riparian vegetation and aquatic animals. The operation of these facilities takes into consideration recreational users and aquatic organisms. During the summer, releases from the reservoirs allow sufficient water levels for recreational use, while stored water is released during the winter to provide water levels adequate to maintain downstream water quality and fish and riparian habitat.[167] However, this adaptive management cannot entirely offset the negative impacts of the reservoirs on the Bow River system.

How do Water Withdrawals Affect Hydrology?

It is important to note that despite the substantial changes to the daily and seasonal flows in this reach of the Bow River, total annual flows have changed little. The hydroelectric facilities generally return all the water they store over the year. Consumptive use of this reach of the Bow River is small and licensed water withdrawals have only slight influences on streamflows, compared to the hydroelectric facilities. Relative to downstream reaches, only a small portion of the Bow River is allocated or withdrawn in Reach 3, and much of the water withdrawn is returned to the reach in the form of treated effluent.

Table 5.1 outlines the water licence allocations for the Bow River in Reach 3 for 2002. The total volume of water licensed for diversion by all users was more than

Table 5.1 Licensed allocation of the Bow River in Reach 3 (2002)[108 193]

Water User	Annual Licensed Allocation (m^3)	Percentage of Annual Average Natural Discharge (%)[a]
Industrial	5,734,460	0.22
Irrigation & Agriculture	590,840	0.02
Municipal	5,149,785	0.21
Other	6,654,180	0.26
Total	**18,129,264**	**0.71**

[a] Average annual natural discharge of the Bow River below Seebe was 2,560,967,404 m^3 (1912-2001)

Table 5.2 Licensed and estimated annual consumption and return flows to the Bow River in Reach 3 (2002)[193]

Water User	Annual Consumption from the Bow River (m^3)		Annual Return Flows to the Bow River (m^3)	
	Licensed	Estimated[a]	Licensed	Estimated[a]
Industrial	2,499,030	2,296,016	3,235,430	2,285,761
Irrigation & Agriculture	590,840	590,840	0	0
Municipal	1,597,357	895,146	3,552,428	1,307,263
Other	1,969,419	1,969,419	4,684,761	244,231
Total	**6,656,646**	**5,751,421**	**11,472,619**	**3,837,255**

[a] When water use reports for each license are absent, the licensed consumption and licensed return flows are used to approximate the estimated consumption and return flows, respectively. This likely overestimates the estimated consumption and return flow data in this reach

18 million cubic metres (m^3) in 2002. These extractions represent less than 1% of the long-term average flow for the Bow River near Seebe, indicating a relatively small use of the river, particularly compared to water allocations in downstream reaches of the Bow River.

In terms of total volume, the allocations within this reach were distributed evenly among industries, municipalities and other licensees. Municipal use includes the Town of Cochrane and other small licences. Canmore is not included because the tables do not include their groundwater and tributary water sources. The "other" category consists primarily of golf courses, but also includes a campground, parks and other tourism operations. Industrial water users of the Bow River within this reach include several quarries, concrete manufacturing plants, a greenhouse, and gas plants. Irrigation and agricultural activities are limited to small private licences and in 2002, made up the smallest proportion of water use.

In 2002, the majority of the water licensed for consumption in Reach 3 was actually consumed by the licensees (Table 5.2). Actual return flows were high, indicating that much of the water used within this reach is returned to the river in treated form. The majority of the return flows come from the industrial and municipal users. In contrast to all other licensees, municipalities returned more water to the system than they consumed. Irrigation/agriculture users provided no return flows.

The municipalities of Canmore, Cochrane, Deadman's Flats, Exshaw, Morley, and Seebe all withdraw water from the Bow River (or its tributaries or from groundwater associated with the river) for domestic and local industrial uses. Canmore, which also services Harvie Heights, has two water supply sources: the Spray Lakes Reservoir system and a groundwater aquifer beneath the town. Since the implementation of a water management program, Canmore's per capita water consumption has dropped from 430 litres (L) per person per day in 2000 to 404 L per person per day in 2003.[113] In 2002, Canmore upgraded its drinking water treatment plant to include ultraviolet (UV) light disinfection that inactivates harmful pathogens and bacteria, *Cryptosporidium* and *Giardia* (beaver fever), that can cause mild to severe gastrointestinal illness.[132] Cochrane also recently improved its drinking water treatment plant to a state-of-the-art facility.

Much of the water extracted for municipal use is returned to the Bow River following treatment. All treated municipal wastewater from Canmore, Deadman's Flats and Exshaw is disposed of directly into the Bow River. In 1997, Canmore upgraded its wastewater treatment system to a tertiary plant. The facility is capable of treating 22 megalitres (ML) per day of wastewater using biological nutrient removal and UV disinfection, prior to its release to the Bow River.[113] Seebe uses a lagoon for wastewater storage.

In 1998, the City of Calgary, due to increased concerns regarding the water quality of the Bow River upstream of the city, began to accept piped wastewater from Cochrane, treating it at the Bonnybrook Wastewater Treatment Plant. This arrangement means that some of the water extracted for Cochrane's municipal use is returned to the river in Reach 5, well downstream of Reach 3.

Oil and gas operations and other industrial users are expected to increase within the Municipal Districts of Bighorn and Rocky View in the future. Municipal use and use by campgrounds, golf courses and other tourism operations can also be expected to increase with increasing population and tourism. Agricultural uses are expected to decrease, in response to a shift away from agriculture toward urbanization.[137]

What's going on in Cochrane?

With a growing population, Cochrane has made progress on water issues and conservation during the past decade. In the mid-1990s, standards for new housing were modified to include low flow toilets and other water saving devices, and conservation kits were provided to existing homes. Rain barrels have been available at a nominal cost and education continues to increase public awareness. Cochrane has completed an audit of all municipal stormwater outfalls and infrastructure and their Stormwater Management Policy, adopted in 2002, requires all new developments to incorporate best management practices.

The town has passed several bylaws to ensure that citizens do not wash vehicles in their neighbourhoods or dump contaminants down storm sewers. The new Escarpment Protection Policy requires a setback from the top of steep slopes to prevent erosion from stormwater discharge. Cochrane has minimized pesticide use, improved development standards, upgraded stormwater channels and instituted an organized street-sweeping program, all to improve the quality of its runoff and stormwater.

Commissioned in 1998, Cochrane now boasts a new state-of-the-art water treatment facility with the capacity to treat water for a population of 18,000. Branches and Banks, a community tree planting effort, completed the planting of 20,000 trees along riparian areas, coulees and pathways to help stabilize streambanks. In 2002, the program received an Emerald Award from the Alberta Foundation for Environmental Excellence. However, there are still challenges to be met for example, contaminated groundwater continues to flow off a former industrial wood preserving site. The former owner of the site, the new developer and provincial regulators are working on remediation plans for this site.

Branches & Banks tree planting

How does Land Use Affect Hydrology?

Reach 3 has had approximately 379 km^2 (8.52%) of its landbase cleared. The major human land use is forestry (see Chapter 2).[123] Historically, forest harvesting within the Kananaskis drainage began in the 1880s and lasted until the 1970s.[17 18] Spray Lake Sawmills has a Forest Management Agreement (FMA) that includes 67,519 ha within the Kananaskis, Jumpingpound and Ghost river sub-basins.[41]

Concerns regarding the impact of forestry activities within the Ghost watershed recently led to a successful court injunction, barring plans for clear-cut logging by small permit holders within a portion of the Ghost/Waiparous sub-basin.[162] Logging plans extended to within a few metres of Waiparous Creek and the Ghost River, with potential impacts on the function of the riparian zone. There is currently no site-specific data on the impacts of forestry on water quantity, however, Spray Lake Sawmills is currently monitoring other drainages in order to best manage their future activities (see Chapter 8).

Some of the land (5.93%) has been cleared for use in grazing. The livestock population consists primarily of cattle and chickens, but also some pigs and sheep.[107] Compared to downstream reaches, the level of grazing and agriculture is small. There is no site-specific data on the impacts of these agricultural land use practices on the water quantity in the Bow River or its sub-basins within Reach 3.

5.3 Water Quality

Overall, the water quality in Reach 3 has not been adversely affected by any major sources of contaminants and is considered to be of high quality compared to downstream reaches.[90 123] The dams along the mainstem and the tributaries of the Bow River act as sediment and nutrient sinks, resulting in relatively low sediment and nutrient concentrations downstream in the river.

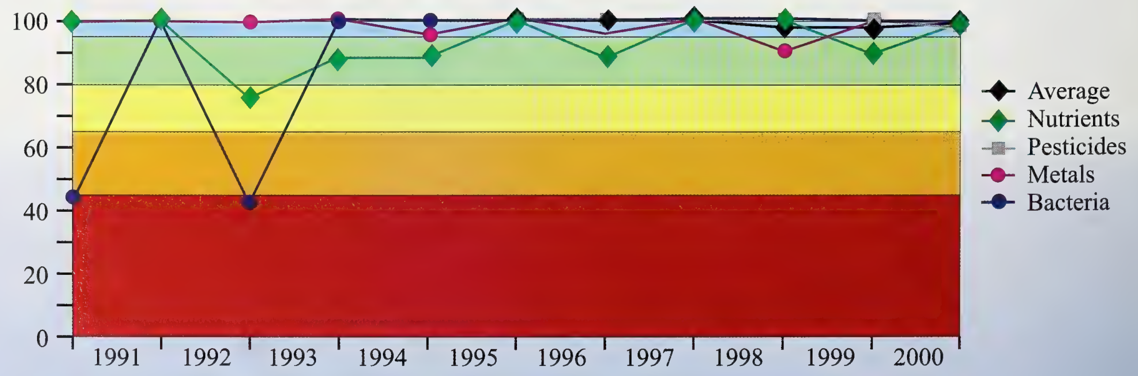
Municipal effluent (stormwater and treated wastewater) from the communities likely influences the river's water quality. Though the human population in these communities has greatly expanded in the last 10 years, improvements in wastewater treatment have resulted in no associated decreases in water quality. Other influences on the water quality of this reach include wastewater effluent and surface water runoff from industry, agriculture, grazing and forestry practices. These non-point source influences are difficult to quantify, and no specific information exists regarding their impact on water quality on Reach 3 of the Bow River.

Water Quality of the Bow River at Cochrane

Water quality within this reach is measured at one site by Alberta Environment as part of their long-term river network (LTRN) monitoring program. The *Bow River at Cochrane* site (Site 00AL05BH0017) is located at the Highway 22 bridge (Figure 5.5, page 76). Recent water quality assessments of data collected at this site include the determination of Water Quality Indices (WQI) for several suites of key variables, including metals, nutrients, bacteria and pesticides (see Chapter 2). An overall average WQI has also been generated, based on the results of the suites of variables (Figure 5.4).[27]

The averaged WQI for the site consistently rated the water quality as excellent from 1996/1997 to 2000/2001. This site captures impacts of the effluent discharged from the Canmore wastewater treatment plant (WWTP), a limestone quarry and several gas plants. It also captures some of the urban runoff and stormwater from the Town of Cochrane.

Figure 5.4 Canadian water quality index for the Bow River at Cochrane[27]



However, the site is situated approximately 3 km upstream of where Cochrane's WWTP historically discharged to the river, so did not capture Cochrane's wastewater effluent during the period when it was discharged. Cochrane's wastewater is now piped to Calgary.

Nutrients rated excellent at the start of the calculation period and ranged from good to fair throughout the 1990s. By 2000/2001, the rating for nutrients had improved to excellent again. Lower ratings in the early 1990s may be due to increased population growth in Canmore and the subsequent increase in the amount of wastewater discharged to the Bow River. Improvements in the nutrient ratings in the late 1990s may be attributable to the upgrades at Canmore's WWTP in 1997. Prior to the upgrades at its WWTP, benthic algae were found to increase downstream of Canmore,[249] suggesting that nutrient loading was occurring.

A synoptic survey of the Bow River from 1994 to 1997 indicated that the Canmore WWTP is the largest human source of nutrients to the Bow River within this reach. The Ghost and Kananaskis rivers and the Spray Diversion Canal, which enters the Bow River at Canmore, are major tributary sources of nutrients to the Bow River system.[249] Sediments, to which nutrients can be bound, are released from the bottom of the Spray Reservoir and discharged to the Bow River via the diversion canal.

Pesticides were not rated until 1995/1996, but were consistently excellent throughout the sampling period. This result is not surprising, in view of the few agricultural activities occurring within the basin at this point. While still rating excellent, a slight decrease in the pesticide rating was found in 2000/2001, due to one slightly higher measurement of 2,4-D, a common commercial herbicide. It is unlikely that this one sample is indicative of an increasing trend in pesticides at this station. Excellent pesticide ratings are expected to continue in the future, especially as Canmore has committed to end the cosmetic use of pesticides (on lawns and parks) by 2014.[69] Additional sources of pesticides may come from the operation of golf courses.

Ratings of metals were consistently excellent over the sampling period, with the exception of 1998/1999. During this time, metals were rated as good, due to a slight increase in a few samples of cobalt, nickel, silver and zinc. These elevated metal concentrations were transient and are of no concern for long-term water quality or aquatic health. The sources of these metals include wastewater effluent from Canmore and natural tributary sources. The Kananaskis River is the largest tributary source of several metals within the entire Bow River system.[249]

Bacteria ratings improved substantially over the sampling period, having rated poor during the 1990/1991 and 1992/1993 sampling periods. All other years were rated as excellent. These poor ratings and their exceptional improvement are deceptive, however, and are more a result of how the index is calculated than any real change in bacterial concentrations.

Canmore Wastewater Treatment Plant – M. Bennett

The poor ratings are due to one fecal coliform sample in each year that exceeded the water quality guideline for livestock watering (more than 100 colony forming units per 100 millilitres). The fact that fecal coliform bacteria were the only bacteriological variable measured during this time also contributed to the low rating (*E. coli* were measured in subsequent years).

While these two bacteria samples were high, there is no other data to suggest that bacterial concentrations were consistently poor throughout these years. Fecal coliforms originate from the intestinal tracts of mammals and the source of this contamination may have been from humans, livestock or wildlife.

This is a good example of how careful interpretation of water quality data is essential to avoid unnecessary alarm, though the indices themselves can be very useful in describing complex water quality data. Regardless, bacterial concentrations may have improved following the upgrades at the Canmore WWTP, including the use of UV light disinfection.

5.4 Ecosystems

Terrestrial Habitat

As the Bow River flows from the foothills of the Rocky Mountains onto the prairie, the landscape changes from the montane sub-region in the western portion of the watershed to the foothills parkland sub-region in the eastern portion. The Ghost River confluence marks the approximate transition. The upper elevations of the mountains also contain sub-alpine and alpine plant communities, while smaller areas of the upper and lower foothills sub-regions are found in the upper elevations of the Ghost River sub-basin (Table 5.3 and Figure 5.5).[19]

The vegetation and wildlife characteristic of the alpine and sub-alpine sub-regions are described in Chapter 3. Within the montane, white spruce, balsam poplar and trembling aspen forests are commonly found on wetter sites, while lodgepole pine, Douglas-fir and limber pine predominate in drier areas. This vegetation

Figure 5.5 Natural sub-regions and measuring locations of Reach 3 [23 39 40 45 195]

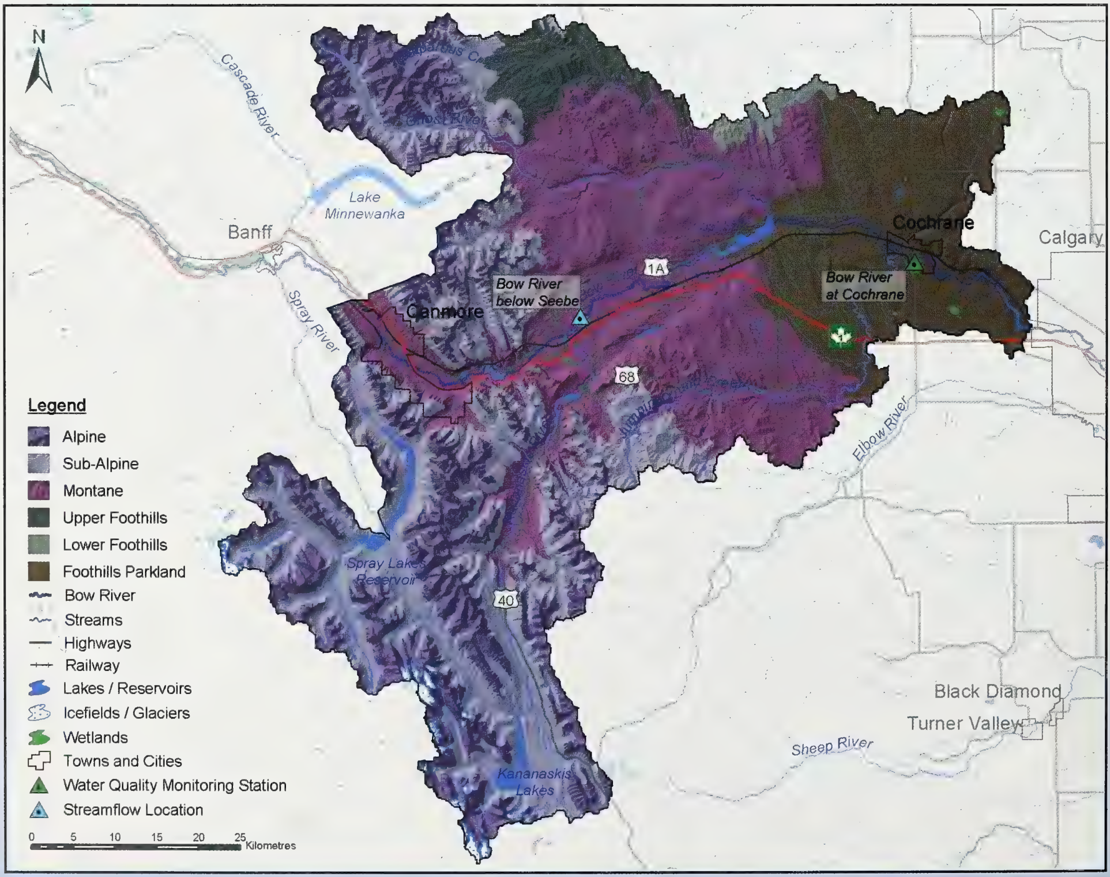


Table 5.3 Size and extent of Reach 3 features[23,39,40,45,195]

Natural Feature	Area (km^2)	Extent of Reach (%)
Icefields	20	0.44
Alpine sub-region	809	18.17
Sub-alpine sub-region	1,144	25.71
Montane sub-region	1,455	32.69
Upper foothills sub-region	145	3.26
Lower foothills sub-region	40	0.89
Foothills parkland sub-region	735	16.51
Lakes	15	0.34
Reservoirs	51	1.15
Wetlands	12	0.27
Rivers	25	0.56
Total	**4,451**	**100.00**

gradually changes to a mixture of balsam poplar, aspen stands and grasslands within the foothills parkland sub-region. Vegetation communities in the foothills parkland are diverse and range from dense deciduous forests to grasslands with groves of trees. Desiccation by wind and low precipitation are major limitations to vegetation. Aspen is generally dominant in the upland forests with balsam poplar occurring on moister sites. Narrow-leaved cottonwood forests occur on shifting deposits along streams. Common shrubs include snowberry and saskatoon. The grassland areas in the east contain a large diversity of forb and grass species.[19]

The upper foothills sub-region is primarily coniferous, with few deciduous forest stands. Forests are dominated by white spruce, black spruce, lodgepole pine, and, occasionally, subalpine fir. Shrubs typically include false azalea, buffaloberry, prickly rose, Labrador tea, and bunchberry. Moist sites often have a well-developed moss layer. In the continued absence of fire, white and black spruce are likely to eventually replace lodgepole pine.[19]

The Bow River Valley and its tributaries provide critical wildlife movement corridors for a variety of animals.[17] Moose, elk, white-tailed deer, mule deer, and black bear are the most common large mammals upstream of Lac des Arcs. Bighorn sheep and mountain goats can be found in the upper elevations.[17]

Farther downstream, where the river valley flows through grassland, deer become the predominant species. The grassland also supports small mammals that are preyed upon by coyote, fox and weasel. The mixture of shrubs and grasses within the eastern portion attract a wide range of bird species, particularly during migration. The increasingly limited availability of habitat, due primarily to clearing for grazing and urban and rural residential development, restricts the number of species that breed and live year-round in the eastern portion of the watershed.[57]

Several areas in the western portion of the watershed are considered nationally or provincially environmentally significant for their diverse and abundant plant and animal life. The Wind Valley near Canmore is of national importance, providing critical habitat for elk and bighorn sheep. Its high diversity of ungulates (sheep, elk, mule deer, white-tailed deer, and moose) support a diversity of predators, including black bear, wolf, grizzly bear, wolverine, coyote, and cougar.[228]

Elk

Riparian and Wetland Habitat

Riparian health within Reach 3 was assessed by the Cows and Fish Program, which found the upper portion of this reach, from Canmore to the Kananaskis Dam, to be healthy. From the Ghost Dam to the Bearspaw Dam, the riparian habitat of the river was rated as healthy, but with problems, due primarily to the presence of undesirable plant species and livestock grazing. Non-native species, which can crowd out native riparian vegetation and reduce the quality of habitat, were widespread. Common invasive plants include Canada thistle, leafy spurge, perennial sow thistle, tall buttercup, and toadflax. The abundance of invasive plants increases farther downstream, corresponding to increasing disturbance from development. Livestock grazing in the lower portions of the watershed is damaging to riparian vegetation and streambanks.[38]

The minimal water extractions that occur within this reach have no significant impact on the overall riparian health of the Bow River. However, the Ghost Dam has reduced the natural flooding of the riparian zone. Because cottonwoods are dependent on flooding for recruitment of new saplings, problems with cottonwood regeneration may occur downstream of dams.[38]

From the Banff National Park boundary to the Lac des Arcs area, the riparian and wetland habitat is similar to that within the Park, except that the riverbanks are generally lower, accommodating more braided channels and associated habitat. These braided channels and backwater portions of the Bow River support a variety of wildlife.

Lac des Arcs is a shallow, windswept lake that is an important staging area for waterfowl during the spring and summer. Between Lac des Arcs and the Ghost Dam, the river provides additional staging habitat for ducks. Mallard ducks are one of the most abundant waterfowl. The area between the boundary of Banff National Park and the Ghost Dam is important nesting and rearing habitat for Canada geese. Other common waterfowl include the American widgeon and tundra swan.[20] Breeding ponds for the long-toed salamander are found at West Bow Flats.[228] Within Alberta, the long-toed salamander has been identified as "sensitive" (see Chapter 2).[44]

Wetland and riparian habitat is limited in much of the eastern portion. However, Yamnuska and Bow Valley Provincial Parks contain springs with some of

Please pick the flowers

During the past decade, infestations of many kinds of weeds have increased throughout Alberta, spreading into the Rocky Mountains and foothills areas. Many of these invasive plants are commonly associated with agricultural crops, which are limited in this area of the Bow River Basin. The movement of grain via the CPR may be a source of these crop weed seeds, a process that illustrates how weeds can be widely distributed from their place of origin.

One plant in particular, the ox-eye daisy, is of increasing concern. Of Eurasian origin, the ox-eye daisy is classified as a noxious weed in Alberta. During the past decade, infestations of this plant have increased, particularly in riparian, disturbed, and agricultural areas. In 2003, the Biosphere Institute of the Bow Valley initiated the Bow Valley Ox-eye Daisy Project, with funding from Environment Canada's EcoAction program and support from local jurisdictions and partners. The goals of this project were to map the extent of infestations along roads and riparian areas in the Bow Valley, to educate the public about the ecological threat posed by invasive species, and to remove (using non-chemical means) ox-eye daisies from areas along the Bow River.

The surveys revealed more weed infestations than expected. The Biosphere Institute continues to work with its local partners to identify areas of concern and to educate the public about the threat to native plants and biodiversity posed by invasive alien species such as the ox-eye daisy.

the highest biodiversity in Alberta, providing habitat for large numbers of migratory birds. Plants include "sensitive" species such as the yellow lady's-slipper orchid. West Bow Flats contains one of the few remaining undisturbed floodplain habitats in the province.[228] The river valley is deeply incised below the Kananaskis and Horseshoe dams at Seebe, and the fluctuating discharges from the Ghost Dam result in poor wetland and riparian habitat.[57]

Aquatic Habitat

As in Reaches 1 and 2, Reach 3 is cold-water aquatic habitat. Above the Kananaskis Falls Dam at Seebe, the river provides important fish habitat, particularly for several species of trout and whitefish. However, historic introductions of non-native fish have impacted native fish populations. Introduced brook and brown trout have been especially successful, largely replacing native cutthroat and bull trout. Rainbow trout, introduced historically in the upper Bow River, have hybridized with cutthroat trout, particularly in the mainstem of the Bow River and in Jumpingpound Creek.[165]

Mountain whitefish, the most common sportfish species, uses the river for spawning and seasonal migrations between overwintering and summer feeding areas. Brook and brown trout are common between the boundary of Banff National Park and Seebe. West Bow Flats is one of the most significant brown trout spawning areas in Alberta, and an important brook trout spawning area.[228] Here, brook and brown trout spawn in side channels, seepage channels and tributaries near Canmore, including Policeman, Bill Griffiths and Canmore creeks. Bill Griffiths Creek is fed entirely by groundwater, and as such, experiences constant flows and stable temperatures, making it one of the best sites for brown trout spawning in Western Canada.[20]

Sections of the Bow River within this reach also provide good rearing, feeding and overwintering habitat for fish.[20] Jumpingpound Creek is an important spawning and rearing tributary for rainbow trout downstream of the Ghost Dam. Other sportfish species found in lower numbers include bull, cutthroat and lake trout and burbot.[57] Brook stickleback, longnose dace and white sucker are the common forage fish found in Reach 3.[165]

The productivity of fish populations is limited by the habitat instability caused by the large hourly flow fluctuations in water released from the dams. Apart from posing a barrier to upstream migration, the Kananaskis Falls and Horseshoe Falls dams have only a limited impact on fish and their habitat because water flows though them relatively unrestricted and no effective reservoirs exist.

The three mainstem dams on the Bow River in Reach 3 also present physical barriers to upstream fish migration; the Bearspaw Dam located at the downstream end of this reach prevents migrations from Reach 4. The cumulative effects of these dams, their consequent fluctuations in flows and occasionally inadequate flows, cause fish habitat connectivity to be of concern within this reach.[123]

The reservoirs in this reach are generally unproductive, as are most mountain reservoirs. The release of water from the reservoirs during the winter results in water levels dropping by several metres. These large annual fluctuations adversely affect the aquatic environment around the margins of the reservoirs, limiting plant and invertebrate growth and the fish populations they support.[115] Despite these habitat limitations, lake, brown and bull trout, as well as lake whitefish, mountain whitefish and burbot, occur in the Ghost Reservoir.[37] It also provides spawning areas for lake trout.

Lake trout and a small population of previously stocked cisco are found in the Spray Reservoir, while bull and cutthroat trout have recently been stocked in Upper Kananaskis Lake.[17] The deep water of the reservoirs also provides overwintering areas for fish in this reach.[57]

The Fisheries and Recreation Enhancement Working Group has recommended the stabilization of water levels in Lower Kananaskis Lake. While a small amount of hydroelectric power production would be lost, stabilization would improve aquatic habitat by permitting the reestablishment of a productive littoral zone. Stabilization would also increase the summer flows in the Bow River during a period of high water withdrawals by downstream users.[115]

5.5 Tributaries

Kananaskis River

The Kananaskis River joins the Bow River, from the south, a few kilometres east of Exshaw. It is located within Kananskis Country, a designated multi-use area with a high level of tourism and recreation. The Kananaskis River drains an area of about 926 km^2, including part of the Alberta Forest Reserve, with about 43 km^2 forming part of Spray Lake Sawmills' 2001 FMA. The Spray Valley Provincial Park, Bow Valley Wildland Park, Bow Valley Provincial Park, Peter Lougheed Provincial Park, and Elbow Sheep Wildland Park protect approximately 867 km^2 (93.6%) within the

Are we losing our native trout?

Bull and westslope cutthroat trout were historically the most common trout in the mountain and foothill section of the Bow river, although they were absent from most high-elevation mountain lakes and streams due to the presence of waterfalls.[illegible] Until recent restocking efforts, cutthroat trout had become virtually absent from the mainstem of the Bow River below Lake Louise, and from nearly all its tributaries, including the Kananaskis River.[illegible] Recent fisheries investigations, however, have found cutthroat trout in several creeks, including Evan-Thomas, Pocaterra, Spotted Wolf, Rocky, and Jumpingpound creeks, as well as in the Ghost River drainage.[illegible] The abundance and distribution of bull trout has also changed greatly during the last century; they are now virtually absent from the mainstem of the Bow River below Bow Falls and from the mainstem of the Kananaskis River.[illegible] They currently spawn in Smith-Dorrien Creek, a tributary of the Kananaskis River.[115]

Overfishing, alteration and loss of habitat due to human development, and competition and hybridization with non-native fish have lead to the decline of the bull and cutthroat trout. Early and unrecorded stocking of non-native fish and the transplant of native fish into naturally fishless rivers and lakes may have begun as early as the arrival of the CPR in the mid-1880s.[illegible] Later, brook, rainbow, brown, and Yellowstone cutthroat trout were stocked in the Bow River and many of the area's lakes to improve angling opportunities.


Bull Trout – BRBC

Within Alberta, the bull trout has been identified as "sensitive" and all bull trout caught must be released. The status of the cutthroat trout is listed as "secure" within Alberta (see Chapter 2).[illegible] There are limits to the number and size of cutthroat trout caught in Alberta, and in several waters, including those within Banff National Park, all cutthroat trout caught must be released. While these native species are not on the brink of extirpation, several management programs are ongoing in the hopes of reviving native populations. Revised fishing regulations have resulted in a substantial recovery of the bull trout population in Lower Kananaskis Lake.[illegible] Alberta Sustainable Resource Development is restocking Upper Kananaskis Lake with both bull and cutthroat trout[illegible] and possible future projects include introductions to Pigeon and West Wind creeks near Canmore.[illegible] These programs are positive signs for the future of these native species.

Kananaskis drainage. The Interlakes and Pocaterra dams are located on the upper portion of the Kananaskis River and have increased the areas and storage volumes of the Upper and Lower Kananaskis Lakes, respectively. The Barrier Dam is located on the lower portion of the river, below Kananaskis Village.

The Kananaskis River Valley provides important wildlife habitat and movement corridors for a variety of large mammals in the Bow Valley and Banff National Park. Elk, deer, mountain goats, bighorn sheep, and black bears are common in the watershed, with smaller populations of moose, grizzly bear and wolf. Berries are abundant along the Kananaskis River Valley and around the shores of the Spray Reservoir. Grizzly bears are attracted to these prime seasonal feeding areas.[17]

The fish populations in the Kananaskis River include brook and brown trout, mountain whitefish and longnose suckers as well as bull and cutthroat trout. Fish habitat for all species in this sub-basin is limited by the fluctuating water levels of the Upper and Lower Kananaskis Lakes, Barrier Lake and the mainstem of the river downstream of the dams (see Section 5.4).[115]

The Kananaskis River also provides important habitat for the harlequin duck, the only duck in North America that migrates from the sea to nest along mountain streams during the summer. A large number of these ducks nest between the Kananaskis Golf Course and Barrier Lake; this area may be critical to maintaining the population. Data collected from 1998 to 2000 indicates this population may be increasing. It has been recommended that no further development or activities, including trail improvement, expansion and development of commercial lodges and shoreline access, be allowed along this section of the river.[213]

The Kananaskis River receives wastewater discharges, both direct and indirect, from Kananaskis Village, Fortress Mountain, Nakiska Ski Lodge, the Kananaskis Golf Course, and campsites and trails that are situated along the river's length. These inputs to the Kananaskis River eventually reach the Bow River.

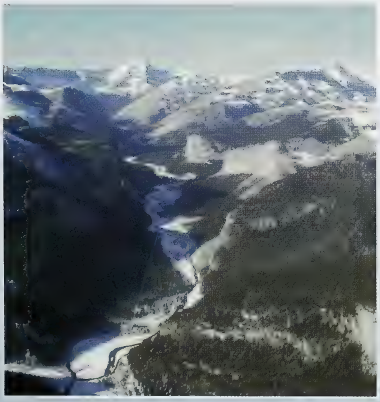
Recreational use of the Kananaskis River is high, with visitors enjoying hiking, camping, biking, riding, skiing, and golfing.[115] An estimated 800,000 vehicles annually travel Highway 40, which parallels the Kananaskis River for much of its length.[18] Excellent whitewater kayaking and canoeing opportunities are provided below the Barrier Dam at Canoe Meadows. When paddling is limited in other natural systems, early and late season flows along this section of the Kananaskis River are enhanced, providing predictable and controllable flows that would not exist naturally.[115]

The multi-use designation of Kananaskis Country raises concerns regarding conflicts between future development and the maintenance of its natural resources. Any future development will be guided by the Kananaskis Country Recreation Policy, which places limits on development and states that total regional environmental impacts must be avoided, managed or mitigated.[34]

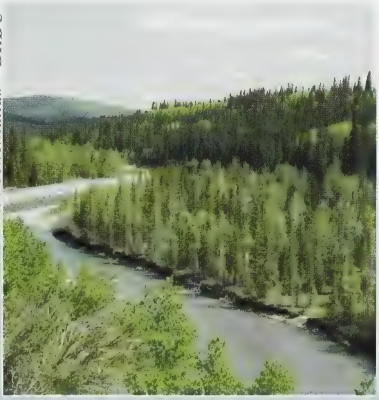
Ghost River

The Ghost River merges with the Bow River from the north, just upstream of the Ghost Dam and approximately 15 km upstream of Cochrane. Like the Kananaskis River, the Ghost River basin is a multi-use area. The Ghost River and its one major tributary, Waiparous Creek, drain an area of about 947 km^2 of high country and forested foothills. A large portion of the sub-basin is part of the Alberta Forest Reserve, with about 340 km^2 of the Ghost sub-basin forming part of Spray Lake Sawmills' 2001 FMA.

Some lands are also provincially protected, including the Ghost Wilderness Area, which covers 152 km^2 of the upper North Ghost, and another 223 km^2 in the northern portion of Don Getty Wildland Park. Flows of the Ghost River have been influenced by the diversion of part of the North Ghost River to Lake Minnewanka (in Reach 2), and by the Ghost Reservoir, which inundates the lower sections of the river prior to its confluence with the Bow River.



Upper North Ghost River – BRBC



Middle Ghost River with benchlands – BRBC

Ghost Reservoir – BRBC

The Ghost watershed provides important wildlife habitat to mule deer, elk, moose, bighorn sheep, black bear, and grizzly bear. Fish in the Ghost River include brook, bull and cutthroat trout, longnose dace, mountain whitefish and longnose sucker.[37]

The watershed is used for ranching, grazing, logging, and oil and gas exploration and production. It also receives many recreational visitors who come to ride, hike and operate various types of off-highway vehicles (OHVs). Industrial activities provide many access routes via exploration and logging roads and seismic cutlines. Random camping is widespread throughout the watershed and formalized campsites are heavily overused during the summer. OHV use is widespread and has lead to localized impacts on terrain, vegetation, water quality, and fish habitat.[37] Appropriate management of camping facilities and OHV use continues to be an issue, one that has increased dramatically during the past 30 years. Clearcut logging under the recent FMA is also poised to begin. Spray Lake Sawmills conduct studies in other drainages to better manage the impact of their operations, but there are no studies ongoing within the Ghost sub-basin.

In 2002, Alberta Sustainable Resource Development began consultations for an access management plan for the area. Views on the use of the area are highly varied. Some of the concerns expressed by stakeholders, including the Alberta Conservation Association, include the efficacy of the multi-use approach, impacts on the watershed and the level of enforcement of recreational use by the Alberta government and the RCMP. Local residents have formed the Ghost Watershed Alliance Society as a result of their concern for the threats to and the condition of the watershed. The society plans to be more active in raising awareness and contributing towards better management of the watershed.

5.6 Where are we Headed?

Water licences currently account for less than 1% of the average flows in this reach of the Bow River. Currently, flows are adequate and provide the current instream flow needs for water quality, fish habitat, riparian vegetation and channel maintenance,[90] although some challenges for fish habitat and cottonwood recruitment have been identified.[38] Phase 2 of the SSRB Water Management Plan will not be recommending water conservation objectives (WCO) for Reach 3,as the priorities were those river reaches downstream of major water withdrawals.

What have been established within this reach are instream flow needs (IFN) objectives for minimum water flows, set for the Bow River between the Ghost Dam and the Bearspaw Reservoir. The IFN objectives are intended to provide a level of protection for fisheries habitat and are dependent on the natural flows, which are computed and updated daily.[28] IFN objectives set for the Kananaskis River upstream of the Barrier Dam and for Waiparous Creek include weekly minimum flow requirements. The IFN objectives for the Kananaskis River downstream of Barrier Dam have also been developed, but have not yet been incorporated into any licence. No water quality-based IFN objectives currently exist for this reach of the Bow River.

Although the seniority of water licences downstream in the Bow River restricts the possibility of additional withdrawals,[28] as population and development increase, water-quality based IFN will likely be required.[90] Thus, in the future, WCO may be set for Reach 3. Urban development is certain to increase, particularly in the communities of Canmore and Cochrane, requiring increased volumes of water withdrawals from and wastewater discharged to the Bow River.

While conservation efforts can go a long way toward reducing the per capita usage of water, demands on water resources will inevitably rise. Increased development and land modification for urban and rural populations, forestry activities and oil and gas production are also expected in the future. Given the increasing trends toward water allocation within this reach, the determination of IFN and WCO for Reach 3 may be a higher priority than when the SSRB WMP was initiated in 1990.

Due to the increasing pressures on water resources, it is important to collect comprehensive information on which to base predictions and make management decisions. Water quantity is currently measured at one site within this reach. Water quality monitoring is also conducted at one long-term river network site. Wastewater treatment plants and industries also monitor the quality of water discharged to the Bow River.

These monitoring programs provide an excellent basis for the status of water quantity and quality in this reach. Information is lacking, however, for land use impacts and non-point sources of pollutants on water quality and quantity. While communities in this reach depend on groundwater for their municipal water supplies, little information on the quality or quantity of groundwater is readily available. Detailed tributary information is lacking and detailed fisheries studies within this reach have not been conducted since the early 1990s. These data gaps represent opportunities to improve the understanding and management of the Bow River within Reach 3.

Chapter 6

City Sunrise – A.MacKeigan

Chapter 6

Reach 4 – Bearspaw Dam to Upstream of the Western Irrigation District Weir

6.1 What is in this Reach?

Within Reach 4, the mainstem of the Bow River flows almost entirely within the City of Calgary. The reach begins below the Bearspaw Dam, 1 kilometre (km) west of the City of Calgary limits in the Municipal District of Rocky View. The river flows downstream through the city for 23 km and ends this reach just upstream of the Western Irrigation District (WID) weir. Although the length of the Bow River within this reach is relatively short, the Nose Creek and Elbow River sub-basins enlarge the drainage basin of Reach 4 to 2,363 square kilometres (km^2) (Figure 6.1).

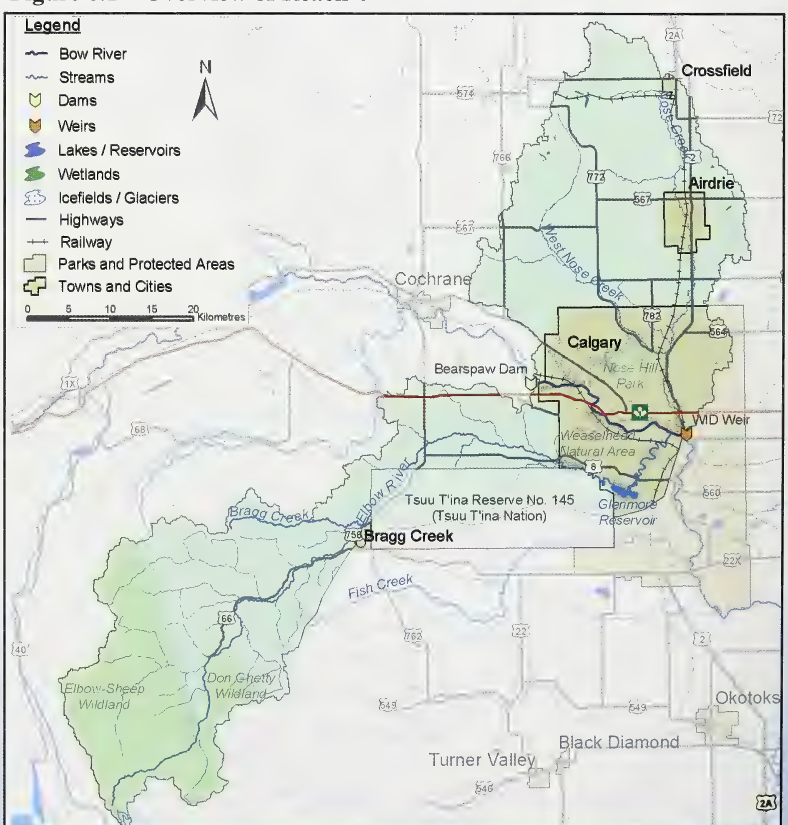
The two major tributaries, Elbow River and Nose Creek, enter the Bow River close to the downstream end of the reach. The Elbow River originates in the mountains and foothills southwest of Calgary. It flows past Bragg Creek, through the M.D. of Rocky View and Tsuu T'ina Reserve No. 145 prior to entering the Glenmore Reservoir. At the Glenmore Dam outlet, the Elbow River flows through Calgary and discharges into the Bow River 2 km upstream of the end of the reach.

The Glenmore Reservoir is operated as a storage reservoir for half the City of Calgary's drinking water supply. It is also used for recreational boating and for flood protection of the densely populated area of the Elbow River floodplain.

Nose Creek drains a primarily agricultural region in the northern portion, beginning at the Town of Crossfield and passing through the Municipal District of Rocky View and the City of Airdrie prior to entering the City of Calgary. It joins the Bow River just upstream of the WID weir. Other small tributaries that once drained directly into the Bow River have been captured in the City of Calgary's stormwater system, with the exception of a few intermittent streams in riverside parks.

Reach 4 of the Bow River and its tributaries drains the front ranges of the Rocky Mountains, foothills, parkland, and prairie areas and includes the alpine, sub-alpine, montane, foothills parkland, central parkland, and foothills fescue natural sub-regions. Parks and protected areas include the Elbow Sheep Wildland Park, Don Getty Wildland Park and Bragg Creek Provincial Park. Parts of Kananaskis Country lie within the drainage area of the Elbow River sub-basin. Within the City of Calgary, several Natural Environment Parks are found along the Bow and Elbow rivers and Nose Creek. Approximately 17.3% of the watershed of this reach has some kind of park status.

Figure 6.1 Overview of Reach 4[16 39 45 75]



Small wetland areas are found throughout the watershed. The Weaselhead Wetlands area in particular provides habitat for resident and migratory birds. However, many wetlands have been lost to agricultural and urban development. The river valleys and riparian areas of the Bow River and Nose Creek have also been impacted by agriculture, urban and country residential development. In contrast, the Elbow River above Bragg Creek has a healthy riparian zone. All provide essential wildlife corridors and habitat.

Reach 4 is the beginning of a productive sportfishery. Mountain whitefish are the most common sportfish species. Habitat degradation and competition from introduced rainbow and brown trout have resulted in declining populations of the native bull and westslope cutthroat trout. While urban development along most of the mainstem of the Bow River has negatively impacted habitat for most fish species, the increased winter flows, a result of hydroelectric facilities, have improved fish habitat during this season.

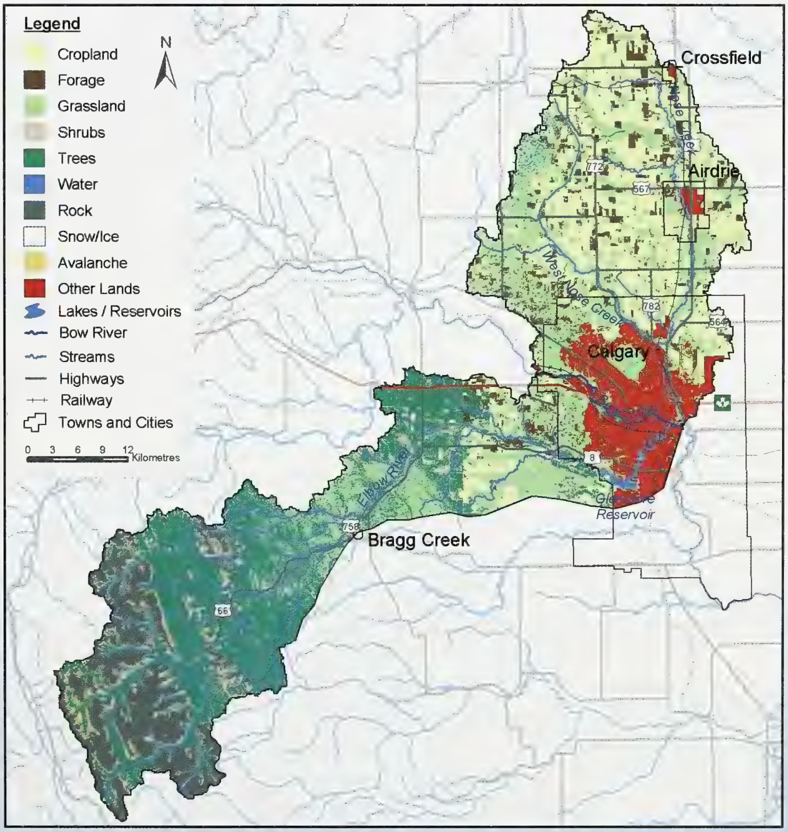
Hydroelectric dams upstream of Reach 4 continue to influence the flows of the Bow River in this reach, but daily fluctuations are moderated by the operation of the Bearspaw Dam. Seasonal impacts from the dams remain, including reductions in the natural peak flows and increases in the natural low flows of the river. Reach 4 marks the beginning of major water withdrawals, primarily for municipal purposes. Changes to the timing and magnitude of the streamflows and to water quality and ecosystem characteristics are discussed in the sections below.

The upper reaches of the Elbow River and Nose Creek sub-basins include forest reserve and agricultural land. Transportation infrastructure (the TransCanada Highway and Canadian Pacific Railway) is also concentrated along the mainstem of the Bow River. However, urban and adjacent country residential developments are the dominant human uses. The urban footprint takes up 441 km^2 (18.7%) of the landbase (Figure 6.2).

The watershed of Reach 4 is one of the two most highly populated reaches in the Bow River Basin, the other being Reach 5. Reach 4 has experienced significant growth in the past few decades. The population of Calgary has increased from 710,000 in 1991 to 922,000 in 2003. The City of Airdrie population grew from 12,000 in 1991 to 24,000 in 2003. Country residential populations along the Nose Creek and Elbow River valleys have also increased in the past decade. These smaller communities brought the total population outside the City of Calgary proper to approximately 60,000 in 2001.[36] Population and land used for residential development will probably continue to expand, while agricultural use will decline. Forecasts estimate Calgary's population will be between 1.15 and 1.5 million by 2026.[80]

Reach 4 supplies the municipal water source for Calgary. Approximately half of Calgary's water supply is drawn from the Bearspaw Reservoir on the Bow River, while the other half is drawn from the Glenmore Reservoir on the Elbow River. Calgary also supplies municipal water to Airdrie and Chestermere. Water for the Tsuu T'ina Nation and the country residential communities along the Elbow River is drawn from the Elbow River and its tributaries and from groundwater sources by local cooperatives and private wells.

Figure 6.2 Land use of Reach 4[6 39 45 254]



Wastewater from these communities is generally treated in septic fields or lagoons. Treated wastewater from Calgary and outlying communities, including Cochrane, Airdrie, Chestermere, and the Tsuu T'ina Reserve, is discharged downstream into Reach 5 (see Chapter 7). As a result, the majority of water quality impacts from wastewater discharge occur downstream of Reach 4.

There are no major agricultural or industrial point source discharges in this reach. The Bow River and its tributaries receive stormwater and surface runoff from Calgary, smaller communities, industries, near by agricultural lands, logging, and gas field development.

This densely populated landbase supports a high level of recreation. Tourism and recreational use are particularly high within the Elbow River drainage.[101] Large numbers of anglers, kayakers, rafters, and canoeists use the Bow and Elbow rivers. Parks and pathways along the riverbanks within the City of Calgary are extensive, and the Glenmore Reservoir is used for sailing, rowing and canoeing. Given the large number of recreational opportunities and the proximity to urban centres, increased levels of tourism and recreational use can be expected in the future.

6.2 Hydrology

The natural flows and seasonal pattern of the Bow River in Reach 4 are illustrated in Figure 6.3, which shows the average discharge of the *Bow River at Calgary* (Water Survey of Canada Station AB05BH004), as measured below the Langevin Bridge (Figure 6.4, page 95). Natural streamflows peak in late June, averaging around 270 cubic metres per second (m^3/s). The natural baseflow averages 25 m^3/s and consists mainly of groundwater that is recharged from the foothills forests and prairie wetlands.[76]

Figure 6.3 also represents the average recorded flows at the *Bow River at Calgary* station. These flows show the modified flow regime as a result of upstream hydroelectric dams, the moderating effect of the Bearspaw Dam and water withdrawals from the Bearspaw Reservoir. The average recorded spring discharge is lower than the natural, and peaks around 190 m^3/s. In contrast, recorded baseflows


Bearspaw Reservoir and Dam – K.Richardson

have increased to an average of 55 m^3/s. Minimum winter flows through Calgary are now more than double what they would be naturally. This change benefits municipal and industrial water supplies as well as the ability of municipalities and industries to meet effluent release guidelines.[115]

How do Dams Affect Hydrology?

The hydroelectric facilities in Reaches 2 and 3 (see Chapters 4 and 5) of the Bow River continue to influence the flow regime within Reach 4. In addition to these upstream hydroelectric facilities, two dams are located within Reach 4 itself (Table 2.4, page 29). In addition to providing some electrical generation, the Bearspaw Dam is used to re-regulate the fluctuating daily water releases from the Ghost Dam. It moderates the daily hydro-peaking that occurs in Reach 3, which results in relatively constant flows within Reach 4.

The small reservoir created by the Bearspaw Dam has only negligible storage capacity and is considered a run-of-river development, with much of the water flowing through the dam as soon as it arrives from upstream. Decisions for storage and release of water in the Bearspaw Reservoir are based on releases from the Ghost Dam, demands of downstream senior water licences and instream objectives.[104]

During the open water seasons, the stabilized daily water flows provided by the managed releases from Bearspaw Dam have numerous benefits. Safety is increased for anglers and recreational boaters. Downtown Calgary is largely protected from flooding and the riverbanks are protected from excessive erosion, reducing the potential for subsequent siltation of the streambed. The increased water level stability also reduces the risk of flooding caused by ice jams.[83]

The Glenmore Dam holds back the flows of the lower Elbow River prior to its confluence with the Bow River. It stores water during the spring and summer, reducing the peak flows of the river. Water is released in order to maintain the instream objectives and stored to reduce downstream flooding. However, the reservoir and dam are not capable of reducing all flood risk within the City of Calgary and a major storm event could result in flooding.

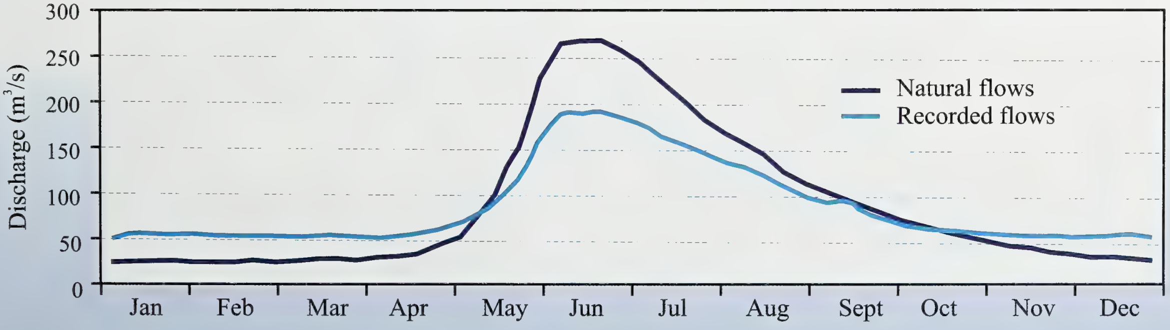
Because the Bow River at Calgary station is located upstream of the confluence of the Elbow River, the influence of the Glenmore Dam on streamflows of the Bow River are not captured in Figure 6.3.

Table 6.1 Licensed allocation of the Bow River in Reach 4 (2002)[108 193]

Water User	Annual Licensed Allocation (m^3)	Percentage of Annual Average Natural Discharge (%)[a]
Industrial	10,974,300	0.38
Irrigation & Agriculture	419,380	0.01
Municipal	351,793,990	12.08
Other	2,054,982	0.07
Total	**365,242,652**	**12.54**

[a] Average annual natural discharge of Bow River at Calgary is 2,912,369,440 m^3 (1912-2001)

Figure 6.3 Discharge of the Bow River at Calgary (1971 – 2001)[29]



What's going on in Calgary?

The City of Calgary has committed to provide leadership to conserve, protect, improve and sustain its environment now and into the future. Environmental priorities related to the protection of water resources include ensuring an adequate supply of good and safe water and protection of the regional watershed, including the headwaters. The city will also ensure that its waste management practices are forward-looking, innovative and effective, and they will protect and acquire key natural areas and green spaces.

In the past decade, Calgary has implemented many projects and initiatives to protect the water resources in the region. The Urban Park Master Plan (1994) guides the development of Calgary's park system associated with the Bow and Elbow rivers and Nose Creek. Stormwater management and erosion and sediment control guidelines have been created and are implemented to help minimize sediment loading to Calgary's waterways. Forward-looking practices in the areas of water quality, best management practices, and the use of constructed wetlands have been promoted.

Over the past several years, it has been mandatory for all new subdivisions in Calgary to incorporate stormwater ponds or wetlands. This requirement is intended to help remove suspended solids and other pollutants before they enter rivers and creeks. A pilot project in a northwest community used "green infrastructure" to mimic natural drainage and to reduce the impact of stormwater. During development, the natural stormwater management system (comprised of wetlands, trees and vegetation) was preserved. Golf courses and parks are encouraged to collect their runoff in ponds and re-use it for irrigation. The city is also conducting a three-year experiment on stormwater re-use at Inverness Park.

Elliston Park and wet pond – K. Richardson

How do Water Withdrawals Affect Hydrology?

Reach 4 marks the beginning of substantial water allocations and withdrawals for consumptive purposes, due here to greater human population and industrial development compared to upstream reaches. Impacts on the Bow River due in part to withdrawals from the Bearspaw Reservoir (but not the Glenmore Reservoir) are depicted in Figure 6.3.

Table 6.1 outlines the water licence allocations for the Bow River in Reach 4 for 2002. Municipal water supplies for the majority of the basin's population are withdrawn from this reach. The total volume of water licensed for diversion by all users was over 365 million cubic metres (m^3) in 2002. These withdrawals represent approximately 12.5% of the average annual flow of the Bow River at Calgary.

By far the largest allocation from the Bow River is for municipal use, which comprises 96% of the total licensed volume of water. Industrial, agricultural and "other" allocations are minimal, each amounting to less than 1% of the average annual flow of the Bow River. Industrial water users of the Bow River within this reach include a quarry and cooling plants. The "other" category consists primarily of golf courses, but also includes the Calgary Zoo. Irrigation and agricultural activities in this reach are limited to small private licences for crop watering and the operation of the Sam Livingston Fish Hatchery.

Water conservation in the City of Calgary

The Bearspaw and Glenmore water treatment plants have recently experienced difficulties with water treatment when water quality in the reservoirs is poor. Poor raw water conditions lower the plants' capacity and occasionally require restrictions on use to ensure that water quality goals are met. In June, 2001, high sediment loads in the Elbow River caused Calgary to place temporary and voluntary restrictions on water use in order to ensure that water quality goals were met. The city subsequently developed a four-stage rationing plan that progresses from limiting lawn watering to once a week for two hours, to a ban on all outdoor water use. Calgary has had good responses by residents when it has appealed for water use restraint during potential shortages. In order to address this issue, as well as meet environmental standards, water quality requirements and projected population growth, upgrades to the water treatment plants have begun. Upgrades to the Bearspaw and Glenmore Water Treatment Plants will improve water treatment and efficiency, including recycling of filter-to-waste and backwash water, and provide both plants with a capacity of 550 Megalitres per day (ML/day), which should be adequate until 2030.

Calgary has launched a major campaign to reduce water consumption. Strategies include education for residential indoor and outdoor water conservation, incentive programs for low-flow toilet replacement, mandatory water metering, incentives to large commercial users, rain barrels available below cost, and replacement of leaky water mains. As of 2002, Calgary requires water meters to be installed for all new accounts. In 1987, 21% of homes were metered; by the end of 2004, this percentage had increased to 73%. Flat rate residential accounts use, on average, 50% more water than those on metered rates.

Programs to reduce the amount of treated water that is lost each year due to leaks and main breaks are ongoing. In 2001, nearly 534 km of pipe were surveyed and all confirmed leaks were repaired, saving approximately 34 million L of water. Through metering, leak detection and strong education programs. In 2002, Calgary achieved a reduction of 7% in the city's peak summer day demand compared to 1987, despite a 39% increase in population. There is still great potential for further reducing consumption through the implementation of a variety of conservation practices, even as Calgary's population continues to grow. The city is taking a broad based approach to demand management that covers system changes, regulation, and community outreach and education. The strategy will be implemented as required to offset the increasing demands of growth.[114]

Table 6.2 outlines the annual consumption and return flows for Reach 4. In 2002, only about 40% of the water licensed for consumption was actually consumed by the licensees. While there is some spare capacity in the total water allocations from the Bow River, daily licence restrictions are the limiting factors for withdrawals, especially in dry summers when the river is at its lowest and municipal demand is at its highest. Actual return flows are high. In the case of industrial and municipal users, most of the water is used, treated, and then returned to the river, though not always to the same reach where the withdrawal took place. Municipal return flows are returned via the wastewater treatment plants in Reach 5 (see Chapter 7). The return water from the fish hatchery is routed through a constructed wetland before it is returned to the river just downstream of the WID weir.

Almost all the municipal withdrawals are allocated to the City of Calgary, which supplies treated water to the City of Airdrie and the Town of Chestermere. A subdivision and water co-operatives on the western edge of Calgary have their own licences. Both the Bearspaw and Glenmore Water Treatment Plants feed into Calgary's distribution system. The City of Calgary withdraws water from the Glenmore Reservoir according to demand and the requirements of the instream flow needs of the Elbow River. Typically, the City of Calgary takes most of its water allocation from the Elbow River, which in 2002 totalled 72,407,851 m^3 (67% of the total allocation). While this withdrawal from the Elbow River is not included in Tables 6.1 and 6.2, it comprises approximately 25% of the average annual natural flow of the Elbow River below the Glenmore Reservoir. A larger percentage of natural flows are withdrawn during low flow years.

It is important to note that the consumption figures in Table 6.2 are the amount of water that is not entirely or directly returned to the water body. Because most of Calgary's withdrawals are returned to the river via wastewater, the consumption is low. Calgary's population has doubled in the past 25 years, but per capita water consumption has been reduced, such that overall consumption has stayed about the same (see sidebar). Per capita consumption has decreased from close to 800 litres (L) per person, per day in 1979, to an average of 516 L per person, per day in 2003.[89] The city's goal is to accommodate growth with the same amount of water it used in 2003. When the population reaches 1.5 million, the per capita consumption target is about 350 L per person, per day.[114] This will help ensure that the total amount of water withdrawn from the Bow and Elbow rivers remains unchanged.

Much of the water withdrawn for municipal use (almost 90%) is returned to the Bow River following treatment. The municipal return flows are measured at the City of Calgary's wastewater treatment plants (WWTPs), which discharge to the Bow River in Reach 5 (see Chapter 7). These treated return flows also include wastewaters pumped from Cochrane, Airdrie, Chestermere, and the Tsuu T'ina Reserve. This arrangement means that much of the water extracted for municipal use in Reaches 3 and 4 is returned to the river in Reach 5. Calgary's water treatment plants currently return the filter bed-waste and backwash water to the river immediately downstream of the plants. This volume is about 15% of the water withdrawn for municipal use.[89] Upgrades currently underway will recycle this water in order to adopt a zero discharge policy from the water treatment plants to the Bow and Elbow rivers.

Table 6.2 Licensed and estimated annual consumption and return flows to the Bow River in Reach 4[193]

Water User	Annual Consumption from the Bow River (m^3)		Annual Return Flows to the Bow River (m^3)	
	Licensed	Estimated[a]	Licensed	Estimated[a]
Industrial	1,761,420	405,688	9,212,880	6,937,102
Irrigation & Agriculture	61,670	61,670	357,710	357,710
Municipal	69,203,260	26,308,380	282,590,730	162,180,000
Other	901,672	842,358	1,153,310	352.780
Total	**71,928,022**	**27,618,096**	**293,314,630**	**169,827,592**

[a] When water use reports for each licence are absent, the licensed consumption and licensed return flows are used to approximate the estimated consumption and return flows, respectively. This likely overestimates the estimated consumption and return flow data in this reach. Data is for 2002

To date, Calgary has not had to restrict water use due to supply scarcity. In 2002, the City of Calgary actually withdrew only about 46% of their licensed allocation from the Bow River (Table 6.2). This spare capacity will accommodate some future population growth and water demand. However, daily withdrawals are restricted by conditions in the river and demands of downstream water users.[114]

How does Land Use Affect Hydrology?

Approximately 849 km^2 (34.54%) of the landbase has been cleared or changed from its natural vegetation. The urban landscape of Calgary has the greatest impact on the mainstem of the Bow River, but agriculture, forestry, resource extraction, recreation, and country residential land uses have substantial impacts on the Elbow River and Nose Creek sub-basins (Figure 6.2).

The land that drains directly into the mainstem of the Bow River is almost entirely within Calgary's city limits. In 2003, Calgary covered an area of 725 km^2, of which 55.8% lies within the landbase of Reach 4. Land used by Crossfield and Airdrie bring the total urban footprint to 411 km^2 (18.7%). The specific land area used by country residential developments could not be calculated with current GIS data.

The increased rate of stormwater runoff in urban landscapes is a significant influence on the river (see Chapter 2). In 2002, approximately 80% of the stormwater from Calgary flowed untreated into receiving waters, with the remaining 20% passing through ponds or constructed wetlands.[59]

Recent changes to provincial regulations require urban areas in Alberta to make improvements to the quality and quantity of urban runoff. Calgary is currently experimenting with a variety of means to improve runoff quality and quantity in older neighbourhoods, while stormwater management systems in new neighbourhoods must meet new criteria and management guidelines.[85 86]

Approximately 286.6 km^2 (12.1%) of the land base is part of the Forest Reserve (see Chapter 2). Spray Lake Sawmills' Forest Management Agreement encompasses 37,664 ha within the Elbow River sub-basin.[41] They have been conducting monitoring programs within their operating area since 1996. Their Aquatic Ecosystem Monitoring Program now includes six tributaries to the Elbow River (see Chapter 8).

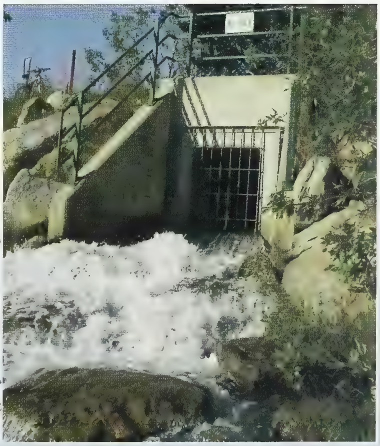
Considering that the Elbow River provides half the drinking water for the City of Calgary, protection of its watershed is critical to maintaining the quantity and quality of water for many of the basin's residents.

Approximately 587 km^2 (24.85%) of the landbase has been cleared for agriculture, with additional lands used for grazing. Estimates on the total livestock population have not been determined. A rough estimate for the portion of Reach 4 that lies within the Municipal District of Rocky View places the number of cattle and horses at around 1,200 and 600 animals, respectively,[99] plus additional numbers of other livestock. Chickens, pigs and sheep are also raised in the Nose Creek sub-basin,[137] and about 1,500 horses and 400 plains bison are found in the Tsuu T'ina Nation lands.[159] Larger numbers of livestock are found upstream of the Glenmore Reservoir in the Elbow River sub-basin.

Production of forage crops is the primary agricultural crop. Compared to downstream reaches, the level of grazing and agriculture is small. See Chapter 2 for a discussion of the general impacts of agricultural activity on hydrology.


Stormwater storage pond – H.Unger


Visible plume on Bow River – M. Bennett


Calgary stormwater outfall – H.Unger

6.3 Water Quality

No recent long-term water quality data exists for Reach 4 of the Bow River. Alberta Environment has monitored water quality for several specific studies and synoptic surveys during the 1990s, but long-term data necessary for producing a Water Quality Index for this reach are not available. Three sampling stations are found in the upstream section of this reach (Figure 6.4, page 95), but they do not capture the majority of the inputs from urban runoff, nor the inputs from the Elbow River or Nose Creek. Stations 00AL05BH2090 *Bow River below Bearspaw Dam* and 00AL05BH2105 *Bow River upstream 85th St. Bridge* were sampled until 1996. More recent data (2001 and 2002) has been collected at station 00AL05BH2095 *Bow River at Valley Ridge Golf Course upstream of Pumphouse*, but the number of water quality variables measured was limited. Data from other sources have been used to describe the water quality and its major influences, to make up for the lack of long-term, strategically located, reach-specific information.

Overall, the water quality has not been adversely affected by any major sources of contaminants. It is considered to be of relatively high quality compared to downstream reaches. Water quality problems with respect to temperature, dissolved oxygen and ammonia were not apparent.[249] In addition, the dams along the mainstem and the Elbow River tributary act as sediment and nutrient sinks, resulting in relatively low sediment and nutrient concentrations downstream.

Because the majority of this reach flows through the City of Calgary, it receives municipal effluent in the form of stormwater. The many small stormwater outfalls result in cumulative impacts on water quality, and contribute sediment, road salt, hydrocarbons, pesticides, metals, nutrients, and bacteria to the receiving waters. Water quality data collected by the City of Calgary indicates that total suspended solids are the biggest concern. Stormwater outfalls within Calgary contribute significant amounts of total suspended solids to the Bow River each year; about 9 times the total TSS loading from Calgary's WWTPs.[79] Compared to Calgary's WWTPs, stormwater outfalls contribute a much smaller proportion of nutrients to the Bow River. The "first flush" of runoff from a storm generally contains the highest concentrations of contaminants. Contaminant loading from stormwater outfalls is also high during spring runoff, as are natural background concentrations of sediment and particulate materials.

Total phosphorus levels in the Bow River at the 85th St. Bridge were found to increase during the 1980s,[220] while dissolved phosphorus increased slightly during the 1980s and 1990s.[73 216] During the same period, total ammonia concentrations were found to decrease slightly, while nitrate+nitrite increased slightly.[216] Natural and human sources of these nutrients likely include stormwater, land runoff and nutrient-enriched effluent from wastewater treatment plants (WWTPs) at Lake Louise, Banff and Canmore. Fertilizer use also contributes to nutrient loading. Improvements in upstream wastewater treatment may result in lower nutrient levels in the future.

Fecal coliforms in the Bow River at the 85th St. Bridge were also found to increase during the 1980s and 1990s.[203 220] Fecal coliforms, which are bacteria found in the guts of mammals (including humans, wild and domestic animals), enter the water from surface water runoff and wastewater treatment plant discharges. The presence of fecal coliforms indicates that the water has been polluted with fecal material and may contain more harmful pathogens with the potential to cause gastrointestinal illnesses. They do not live long in surface waters, and the effluent discharged from upstream WWTPs is the major source to the Bow River in this reach.[203] Subsequent improvements in bacteria inactivation at these WWTPs can be expected to decrease bacterial concentrations.

Calgary's Integrated Pest Management Program

IPM is a healthy approach to keeping pest populations (weeds, insects, diseases, etc.) under control. The city's goal is to manage Calgary's 9,088 ha of green space effectively, using environmentally sound methods. Calgary's Parks Department uses IPM in all necessary pest management activities. Since pest problems often point to ecological imbalances, the IPM program manages ecosystems in order to prevent organisms from becoming pests in the first place. Selection of the least toxic alternative is also part of the basic IPM program. The intensity of pesticide use within city parks appears to be declining as IPM practices are integrated. However, only a few pesticide-free parks have been established to date. Parks also educates and promotes IPM to other city departments and to the public.[84]

Stormwater from urban centres can also contribute pesticides to receiving streams. Calgary's Parks Department uses an Integrated Pest Management (IPM) Program for landscape maintenance, which reduces reliance on pesticides. The intensity of residential use of pesticides is generally four times that of city parks and accounts for 70% of the total use of fertilizer and pesticides within Calgary.[30] Pesticide concentrations may be expected to decline in the future, as education programs aimed at the public increase the adoption of more widespread IPM practices. Organic contamination from a former industrial site has been a pollution concern, but containment has been implemented and impacts on the river have been minimized.[218]

Calgary's current provincial approval to operate a stormwater system is in effect from January 1996 until November 2005. Under this approval, the city is required to plan, design, construct and manage the operation of the stormwater system (and wastewater system, as discussed in Chapter 7) to comply with total loading limits for several water quality parameters.

A proposal by the City of Calgary currently under review by Alberta Environment recommends that future stormwater management should focus on total suspended solids. All new subdivisions are currently required to remove 80% of the total suspended solids that are 75 microns and larger. This requirement will be increased to 85% removal by 2006. In addition, a maximum daily value for total ammonia has been recommended for all stormwater outfalls combined.[77]

A stormwater management strategy has been developed in order to best manage and treat stormwater to reduce these impacts on the water quality of the Bow River and to meet the recommended total loading limits. Calgary is retrofitting systems in some older neighbourhoods and requiring new neighbourhoods to build systems that slow the release of stormwater, but stormwater problems have not been fully alleviated.

Stormwater retention ponds reduce peak flows but not total volume. Nor do they reduce dissolved pollutants and those attached to fine sediment particles.

In contrast, the use of constructed wetlands has been found to significantly improve stormwater quality. Calgary has developed several constructed wetlands for stormwater management. The Elbow Valley Constructed Wetland, constructed for demonstration purposes, has shown how effective these wetlands are. With appropriate plant species and hydraulic designs, constructed wetlands can remove the biochemical oxygen demand, suspended solids, nutrients, metals, organic pollutants and micro-organisms from stormwater. A high proportion of Calgary's stormwater is generated during the summer months, when wetlands are most capable of removing nutrients.[46]

Filter-to-waste and backwash waters discharged by the Bearspaw and Glenmore water treatment plants can also impact water quality of the Bow River. Contaminants were found to exceed water quality guidelines for the protection of aquatic life.[211] While the Glenmore plant dechlorinates this water, the wastewater from the Bearspaw plant does include some chlorine residuals, which will be eliminated in 2005. Future upgrades to the plants include recycling the wastewaters, and eliminating the discharges and accompanying pollutants to the rivers.

Other influences on the water quality of the Bow River in the lower part of this reach include inputs from the Elbow River and Nose Creek tributaries. Nose Creek was found to be one of the largest tributary sources of nutrients throughout the Bow River Basin. Along with the Elbow River, Nose Creek is also one of the largest tributary sources of fecal coliforms and *E. coli* to the Bow River Basin.[249] The nutrients and bacteria likely originate from surface runoff, since no municipalities except Crossfield directly discharge wastewaters to these tributaries. Wastewater from Airdrie is pumped to the Bonnybrook treatment plant, while rural residential areas use septic systems or lagoons. Water quality of the sub-basins themselves is discussed in Section 6.5.

Elbow Valley Constructed Wetlands – D.Elphinstone

The use of chlorine in water treatment

Most water treatment plants, including Calgary's Bearspaw and Glenmore plants, use chlorine to disinfect the water. Chlorine is also effective in oxidizing metals and removing some taste, odour and colour compounds from the water. While this makes the water more pleasant and safer to drink, some environmental and health concerns are associated with the use of chlorine. A small amount of residual chlorine remains in the drinking water once it is released from the plant to provide adequate disinfection within the distribution system. Chlorine can also react with naturally occurring organic materials in the water, producing potentially carcinogenic by-products such as trihalomethanes and haloacetic acids.[211] The aging Glenmore Reservoir is susceptible to algae growths, which are thought to contribute to unpleasant taste and odour concerns, and thus, require additional chlorine for adequate treatment. This increases the potential for the formation of chlorination by-products. Regular testing of chlorination by-products indicates that the concentrations in the water at Calgary's treatment plants and within the distribution system are well below water quality guidelines.[84]

Potassium permanganate is a chlorine alternative that doesn't produce these by-products. However, while potassium permanganate can effectively deal with taste and odour issues, it cannot adequately disinfect water.[211] Ozone and ultraviolet (UV) light have been used as alternatives to chlorine for disinfection purposes. Another advantage of these technologies is that, unlike chlorine, they can inactivate protozoa such as Crypotosporidium. Cryptosporidium can be found in water contaminated by mammals and can cause mild to severe gastrointestinal illness.[illegible] Current plans for upgrades to Calgary's water treatment include better management of chlorine residuals, while other modifications to the chlorination system are being considered.[211]

Glenmore Reservoir and water treatment plant – R. Morin

6.4 Ecosystems

Terrestrial Habitat

The landbase of Reach 4 covers a diverse range of ecosystems and habitats. The landscape changes from the Rocky Mountain region in the west, to the parkland region in the north and central portions, to the grassland region in the east. Natural sub-regions within the landbase include alpine, sub-alpine, montane, foothills parkland, central parkland, and foothills fescue (Table 6.3 and Figure 6.4).[19]

Virtually all of the Bow River in this reach flows inside the urban environment of Calgary. About 6% of the Elbow River and 20% of the Nose Creek sub-basins are also located within the city or other urban centres. As a result of urban development, the majority of the natural vegetation and wildlife habitat has been eliminated along the mainstem of the Bow River.

Natural regions, however, include the upper elevations of the Elbow Valley, which contain sub-alpine and alpine sub-regions and create a transition to the montane and foothills parkland sub-regions along the lower sub-basin. The western portion of the Nose Creek sub-basin includes the central parkland sub-region, while the eastern portion includes the foothills fescue sub-region. The vegetation and wildlife characteristic of the alpine and sub-alpine sub-regions are described in Chapter 3; those of the montane sub-region in Chapter 4.

The foothills parkland sub-region is a transitional area between the montane forests and foothills fescue grasslands. Vegetation communities are diverse and range from dense deciduous forests to grasslands with groves of trees. Desiccation by wind and low precipitation are major limitations to vegetation. Aspen is generally dominant in the upland forests, with balsam poplar occurring on moister sites. Narrow-leaved cottonwood forests occur on shifting deposits along streams. Common shrubs include snowberry and saskatoon. Large numbers of glacier lilies, which bloom in early to mid-May, are a distinctive characteristic of the forest within the Elbow River sub-basin. The grassland areas in the east contain a large diversity of forb and grass species.[19]

Like other aboriginal lands in the province, parts of the Tsuu T'ina Nation have never been tilled and are considered provincially significant for containing some of the largest, relatively intact parcels of foothills parkland in Alberta.[228]

The central parkland sub-region is characterized by grasslands, with rough fescue dominating most sites. Western porcupine grass is common on south-facing slopes and hardpan soil areas. This hardpan is the result of saline soils and severely restricts root and water penetration. Other grasses found in hardpan areas include June grass and western wheat grass.[19] In much of the sub-region, however, native vegetation is scarce due to the high productivity of the soils for agriculture.

Native vegetation in the foothills fescue sub-region is characterized by grass species such as fescue and oatgrass. A variety of native flowering plants and herbs is found, with shrubby cinquefoil common in well-

Figure 6.4 Natural sub-regions and measuring locations of Reach 4[23 39 40 45 195]

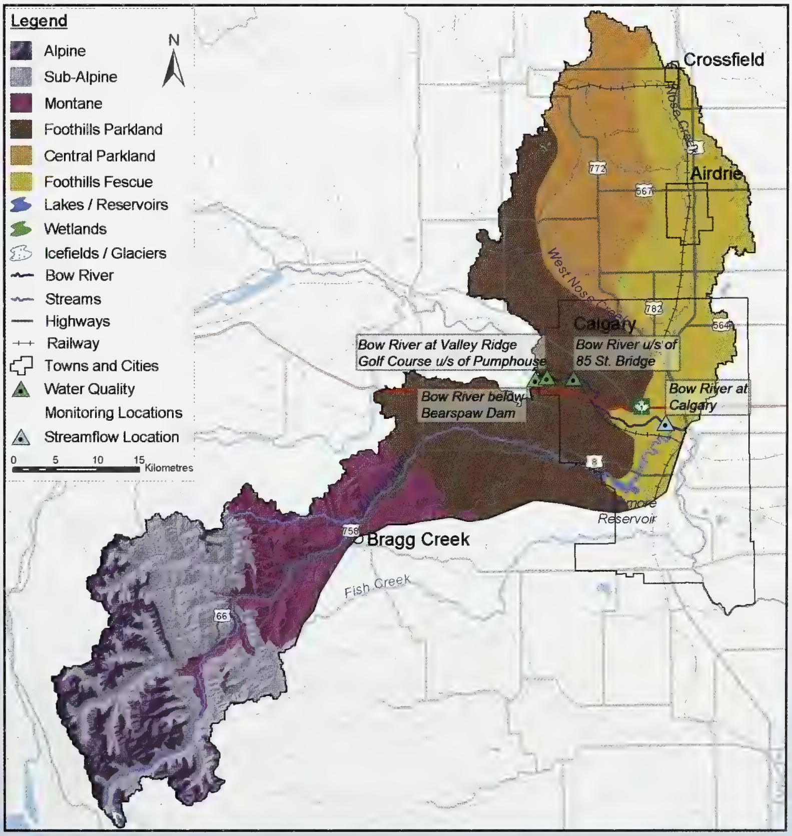


Table 6.3 **Size and extent of Reach 4 features**[23 39 40 45 195]

Natural Feature	Area (km^2)	Extent of Reach (%)
Icefields	1.0	0.04
Alpine sub-region	195.5	8.27
Sub-alpine sub-region	400.7	16.96
Montane sub-region	278.8	11.80
Foothills parkland sub-region	643.7	27.25
Central parkland sub-region	351.4	14.87
Foothills fescue sub-region	468.5	19.83
Lakes	1.3	0.05
Reservoirs	5.1	0.22
Lagoons	0.2	0.01
Wetlands	8.5	0.36
Rivers	7.9	0.34
Total	**2,362.6**	**100.00**

drained areas where grazing pressure is high. Deciduous shrub and tree communities develop where water is locally more abundant, particularly along rivers and on north-facing slopes.[19]

The wide variety of vegetation communities supports many species of wildlife. Within the Elbow River sub-basin, bighorn sheep are found at higher elevations, and black bear, grizzly bear, cougar, moose, elk, and mule and white-tailed deer are found throughout Kananaskis Country. Farther east and north, where grasslands dominate the Nose Creek sub-basin, deer are the most common species, but small mammals that are preyed on by coyote, fox and weasel are also common. The mixture of forests, shrubs and grasses attracts a wide range of bird species, particularly during migration periods in both spring and fall. Birds using the grassland areas include the upland sandpiper, Sprague's pipit and Baird's sparrow. Increasingly, natural habitat is being cleared for urban and rural residential development.

Despite the loss of habitat and connectivity with natural environments, wildlife still use the urban and agricultural lands. Coyotes, snowshoe hare and white-tailed and mule deer are common throughout Calgary. Habitat is also available for moose, red fox, badger, porcupine, beaver, and muskrat.[81] Local and regional parks and open space systems within Calgary provide additional habitat. Nose Hill Park, at 1,127 ha, is the largest municipal park in Canada. Native vegetation in this park contains foothills fescue communities, including shrubs and stands of aspen and balsam poplar. However, extensive recreational use of the park has led to the creation of over 300 km of undesignated trails, negatively impacting native vegetation and wildlife and bird habitat. Other large parks in Calgary include Bowmont Park, Edworthy Park/Lawrey Gardens and Confluence Park.

The Weaselhead and Griffith Woods Natural Environment Parks are found along the Elbow River. Both areas are significant for their biodiversity and wildlife, with Griffith Woods containing a provincially significant forest of mature white spruce. These areas are also the only places where the city does not manage beaver populations. Within them, beaver play a role in maintaining a diverse forest of trees and shrubs of different ages.[106]

Riparian and Wetland Habitat

Within Reach 4, the riparian areas of the Bow River have been negatively impacted since urban development began a century ago. Riparian health was assessed by the Cows and Fish Program, and was found to be healthy, but with problems.[38] These problems include the presence of undesirable plant species. Non-native species, which can crowd out native riparian vegetation and reduce the quality of habitat, were diverse and widespread.

Native grasses were rare, and invasive plants such as smooth brome, Canada thistle, and other weed species were prevalent.[38] Isolated patches of purple loosestrife have been found growing along the streambanks of the

Trees along Calgary's Memorial Drive

In the park space between Memorial Drive and the Bow River, mature poplar trees are part of the riparian vegetation. A total of 3,278 trees were planted in the 1920s as memorials to soldiers of the First World War. These trees are now nearing the end of their life cycle. The City of Calgary is currently planning the regeneration and revitalization of Memorial Drive, which focuses on improving the aesthetic value of the landscape by introducing a variety of new tree species. In order to maintain the trees' heritage, the original trees have been cloned, with 1,500 saplings currently growing.

How is Calgary protecting its remaining wetlands?

A recent inventory conducted by Calgary Parks and Ducks Unlimited Canada found as many as 8,000 wetlands on the edges of the city. The majority are temporary or ephemeral wetlands, but several are large permanent ponds. These remaining wetlands represent only a fraction of what was originally present. In 1981, it was estimated that 78% of the pre-settlement wetlands in Calgary had been lost to development; today that estimate is closer to 90%. Calgary's rapid growth and development continues to expand into wetlands, some of which are considered regionally and provincially significant.

Calgary has recognised the need to better protect these remaining wetlands and has developed a Wetland Conservation Plan to help guide development. The plan is the result of more than two years of consultation and research in cooperation with the federal and provincial governments, conservation groups and the development industry. The plan defines priorities and best practices for wetland protection. A target of no net loss of wetlands has been set, with a focus on protecting the most important and sustainable wetlands. When impacts cannot be avoided, compensation for lost habitat will be considered through wetland restoration or creation.

One of the challenges will be to properly identify the hydrological and biological functions that the wetland provides and to seek ways to ensure these functions are maintained or restored. It may be possible to protect a wetland, but ultimately lose its significance for wildlife as the surrounding area is developed. A detailed implementation plan is also underway that will develop wetland assessment and mitigation tools.

Natural wetland - H.Unger

river within this reach. Since the initiation of the Alberta Purple Loosestrife Eradication Program in 1994, control measures have significantly reduced plant numbers within Calgary.[14]

Tree and shrub cover along the riparian zone within this reach has been reduced, and is much less abundant than in upstream reaches. Riparian forests along the Bow River within Calgary typically exist on prominent point bars and close to the banks of the river. Balsam poplar is the dominant tree species.[240] White spruce stands may be found along the moist, shady, north-facing banks of the river. Spruce trees exist in mixed stands with balsam poplar and/or aspen, or in a mixed coniferous forest in association with Douglas fir.

Aspen are found in isolated stands or as a component of mixed forest. Large continuous aspen stands in Calgary, exist mainly along escarpments, in ravines, and in areas of minimal urban development or disturbance.[38 126] The Cows and Fish Program considered the regeneration and establishment of trees and shrubs within this reach to be excellent.[38] This finding is not surprising, considering that livestock grazing does not occur along the Bow River within this reach, but it also indicates little browsing by wildlife species.

Calgary maintains much of its riparian areas and riverbanks as naturalized park. While dominated by non-native grass and weed species, these areas remain important habitats for birds and small animals.[82] Portions of Pearce Estate Park, found at the downstream end of this reach, provide important songbird migration and overwintering habitat.[240]

Human alterations to the streambanks were found to be another major riparian issue.[38] The riverbanks are armoured and diked throughout the City of Calgary, rendering much of the floodplain non-functional.[90 126] In their natural state, the streambanks are comprised of cobbles and boulders, and most bank areas have good vegetation cover above the water. However, about 15% of the streambanks within this reach consist of man-made rip-rap fill or vertical walls that are used for stabilization and erosion protection, particularly on meander bends and through the city core.[126]

These streambank alterations result in reduced accessibility of the river to its floodplain. The operation of upstream dams and water extractions that occur within this reach also reduce the natural flooding of the riparian zone. The re-regulation of flow by the Bearspaw Dam provides benefits to aquatic habitats, but has negatively impacted riparian vegetation.

Balsam poplar requires a cycle of flooding followed by extensive dry periods; flood stabilization has reduced this cycle, and as a result, regeneration may be of concern in the future.[38] Thus, white spruce, shrubs and non-native grassland may gradually replace the balsam poplar within Calgary.[88]

The Glencoe Golf and Country Club

The Glencoe Club consists of 170 ha in the lower Elbow River valley, and includes managed and unmanaged forested and riparian areas. The Club has adopted a pro-active approach to sustainable management practices. Surface water quality is monitored bi-weekly and after rainfall events for concentrations of nutrients, dissolved oxygen, electrical conductivity, and pesticides. Vegetative buffer strips are used to decrease the runoff of nutrients from the golf course directly into surface water. The application of fertilizer is based upon tissue and soil sampling to ensure only the required amounts are applied to achieve maximum plant health and to reduce excessive surface run-off or leaching.

Irrigation water usage is monitored and modified when necessary to maximize efficiency while optimizing turf health. The use of drought tolerant turf species and native grass areas are encouraged to reduce overall water consumption. The Glencoe Club is also in the planning stages for a complete irrigation system replacement by 2006. Integrated Pest Management Strategies (IPM) are employed as part of the pest control program. Threshold levels for pest populations and acceptable damage levels are used as a decision making tool. Through IPM, pesticides are used as a last resort to effectively control turfgrass pests.

Many wetlands have been significantly altered or eliminated over time. As the City of Calgary has grown, development has drained or filled in over 90% of the wetlands once found within its limits. Today, the majority of wetlands are found in the northeast portion within the central parkland sub-region, and many of these are slightly to strongly saline.[19]

Wetlands are also associated with the river systems. Wetlands along the Bow River within Reach 4 have been virtually eliminated due to streambank and urban development. Despite these changes, waterfowl are common along the Bow River though Calgary, with the banks used extensively by nesting Canada geese. Waterfowl habitat along the Bow River also occurs in the backwater and canals at Bowness Park, Prince's Island and the Calgary Zoo. Pelicans, cormorants and mergansers are often seen fishing at the WID weir.[43]

The meandering Elbow River sub-basin has many wetlands, associated with the main channel and in the form of oxbow lakes.[88] Large wetlands are associated with the Weaselhead Natural Area upstream of the Glenmore Reservoir. The Weaselhead area and the Glenmore Reservoir provide valuable habitat for resident and migratory birds, including swans, geese, shorebirds, ducks, grebes, and loons.[240]

Recently, construction began on the Bow Habitat Station, a freshwater and fish education centre that will incorporate the 17.5 ha Pearce Estate Park Interpretive Wetland. This wetland demonstrates various aquatic habitats, illustrates how wetlands function and features a constructed stream, subsurface treatment wetland, marsh, backwater areas and a floating fen.

Aquatic Habitat

As in upstream reaches, Reach 4 provides cold-water aquatic habitat. Modifications to the natural flow regime of the river, through higher winter flows and re-regulation by the Bearspaw Dam, have benefited aquatic habitat. Downstream of Reach 4, wastewaters and nutrients discharged to the river stimulate biological production.[90] These factors have resulted in the stretch of the Bow River downstream of Calgary being considered a world-class fishery, particularly for rainbow and brown trout.[133]

Mountain whitefish is the most common species. Like upstream populations, historic introductions of non-native fish have impacted native fish populations. The introduced rainbow and brown trout have been especially successful and have largely replaced native species. Over the past decade, the spawning success for these introduced species has increased.[124]

Native cutthroat and bull trout once ranged from the headwaters to beyond Calgary, but are now rare in the mainstem within this reach.[165] The bull trout is listed as "sensitive" within Alberta (see Chapter 2), and all bull trout caught must be released. The status of the cutthroat trout is listed as "stable" within Alberta.[44] Other fish found in lower numbers within this reach include brook trout, white sucker, longnose sucker, northern pike, burbot, longnose dace, and spoonhead sculpin.[124 191]

In Bragg Creek, a tributary of the Elbow River, native cutthroat and bull trout have been extirpated due to competition from the brook trout, which was first introduced and stocked in the Elbow River in 1940.[163 238] In Quirk Creek, another tributary of the Elbow River,

Angling in the Elbow River - S.Mason

Trout Unlimited Canada and the Alberta Fish and Wildlife Division jointly conduct the Quirk Creek Brook Trout Suppression Project. This project's objective is to facilitate a recovery of the native cutthroat and bull trout populations by harvesting as many brook trout as possible with the assistance of anglers who have passed the fish identification test.[238]

For over 30 years, the Government of Alberta has operated the Sam Livingston Fish Hatchery, located at the downstream end of this reach near the WID weir. The hatchery is the largest indoor trout hatchery in Canada. It rears rainbow, brook, brown, and cutthroat trout and occasionally bull trout and Arctic grayling for stocking Alberta waters. None of the fish are released into the Bow River. Fish are stocked to create fisheries in lakes where natural reproduction does not occur, to reduce fishing pressure on native fish populations, to replenish depleted stocks and to provide new fishing opportunities to the public.

Enough habitat variability is found within the mainstem of the Bow River, the deep water above the WID weir and along the lower reaches of the Elbow River to support all salmonid life cycle requirements. Diverse substrate and channel types include potential spawning, nursery, rearing and adult feeding habitats.

The majority of the length of the Bow River within this reach provides suitable spawning habitat for mountain whitefish.[124] Optimum spawning habitat is also available to brown trout within Calgary.[90 238] Rainbow trout spawning habitat is available downstream of the Bearspaw Dam,[124] but has become more limited in the rest of Calgary due to habitat deterioration.[125] Overwintering habitats are most common in the deep water above the WID weir, but enhanced winter flows produced by the upstream hydroelectric dams have also increased overwintering habitat along the mainstem of the entire reach.

Elbow River Watershed Stewardship Groups

The City of Calgary and the Elbow River Watershed Partnership (EWRP) have been working to develop programs to help protect the watershed of the Elbow River sub-basin and improve raw water quality in the Glenmore Reservoir. They aim to reach local landowners, industry and students with education and stewardship opportunities. One new project is the Cattle Set-back Program that gives financial support to farmers toward the purchase of fencing supplies or for hiring fencing contractors to keep cattle away from the river. This program also supports the construction of dugouts as the source of drinking water for cattle. The Water Quality Committee of the ERWP will work to bring together scientists and water quality specialists to create background information on watershed protection that can be used by government policy-makers and industries when making decisions about the watershed and its protection.

Working more directly with ranchers, the Farmers of the Elbow Watershed (FEW) invited the Cows and Fish Program to assess the status of the riparian environment along the river. The mainstream of the Elbow River was found to be "healthy but with problems." Individual farms were also assessed, providing FEW ranchers with opportunities to improve riparian conditions on their property by implementing better cattle management practices. These ranchers have initiated Habitat Enhancement Projects and have set aside their most important riparian areas as environmental reserves, excluding access by cattle. They have also developed Environmental Farm Plans with each member intensively assessing the environmental risks on his property including range management practices, chemical and fertilizer use, water sources, and waste disposal with the goal of amending inefficient or detrimental practices.

Watershed group volunteers – Elbow River Watershed Partnership

Along the Elbow River, the area from Elbow Falls to Canyon Creek provides a silt-free habitat, which is the key spawning area for bull trout in the lower Elbow River.[226] Below the Glenmore Dam, the Elbow River provides important spawning sites for brown trout.[90]

The Bearspaw Dam and WID weir located on the mainstem of the Bow River in Reach 4 have significant effects on fish populations, migration and habitat. These barriers reduce fish habitat connectivity among upstream and downstream reaches. The Bearspaw Dam prevents the upstream migration of fish to the upper reaches of the river, while the WID weir limits movement at the lower end of the reach (see Chapter 7).

The dams and water withdrawals also influence the flows and aquatic habitat of the Bow River. In winter, higher flows provide benefits to aquatic habitat. Peak flows during the spring are reduced, but there is still enough volume and velocity to scour and flush sediments from the spawning beds.[152]

Higher winter flows have been implicated in reducing the scour required to remove aquatic plants, which can grow to nuisance levels in areas enriched by nutrients. Compared to downstream reaches, however, there is little growth of rooted aquatic plants within this reach. While flows at the Bow River at the 85th St. Bridge decreased slightly from 1983 to 1996, no differences in the growth of algae and rooted aquatic plants were found during this period.[216]

The release of poor quality water from urban stormwater outfalls can have negative impacts on aquatic life growth and survival. Bridge construction, channelization, bank stabilization and other instream activities temporarily increase erosion and sediment concentrations,[90] which can impair spawning areas and benthic habitat. In the early 1990s, the abundance of environmentally sensitive benthic invertebrates including caddisflies and stoneflies were found to be significantly reduced downstream of an organically contaminated site along the Bow River within Calgary. These species were generally replaced by less sensitive snails and craneflies.[130]

Subsequent clean-up efforts have successfully contained the contamination[217] and the aquatic community can be expected to recover.

6.5 Tributaries

Elbow River

The Elbow River originates at Elbow Lake within the eastern ranges of the Rocky Mountains. The Glenmore Dam forms the Glenmore Reservoir at the lower end of the Elbow River. The river's drainage basin is 1,235 km^2 in area; it flows for 108 km from the headwaters to the Glenmore Reservoir. Below the reservoir, the river flows through the City of Calgary for another 11 km before its confluence with the Bow River, 2 km upstream of the lower end of Reach 4. Tributaries include Bragg, Canyon, Lott, and Quirk creeks.

From the headwaters to the reservoir, the Elbow River is a fast flowing, cold-water ecosystem. Within much of the headwaters, it exists as a single channel that is deeply incised into canyons. The Elbow Falls are approximately 5 m high and provide a natural barrier to upstream fish movement. Along the agricultural mid-region, the river forms a meandering braided channel, which flows into the Weaselhead wetlands complex just upstream of the Glenmore Reservoir. Below the reservoir, the river is deeply incised in a glacial meltwater channel before it emerges on to the broad floodplain of the Bow River.

Glenmore Reservoir – City of Calgary

The landbase of the Elbow River sub-basin contains diverse vegetation communities. From the eastern ranges of the Rocky Mountains, it flows through the alpine, sub-alpine, montane and foothills parkland sub-regions before reaching the outskirts of Calgary.

In contrast to the Bow River, the Elbow River above Bragg Creek has a healthy riparian zone. Riparian forests in the lower end of the Elbow River sub-basin consist mainly of mature balsam poplar, with small stands of white spruce, aspen and Douglas fir. Natural flooding of the riparian zone occurs along the Elbow River from the headwaters to the Glenmore Reservoir,[88] while downstream reaches within Calgary are protected from most flooding by the management of the Glenmore Dam.

The mountains and foothills in the upper extent of this sub-basin are home to a wide variety of wildlife. Large mammals include elk, deer, mountain sheep, moose, bear, coyote, and cougar. The extensive wetland areas upstream of the Glenmore Reservoir provide habitat for resident and migratory birds, however some habitat has been lost to agricultural and urban development. The river valley is essential for wildlife, particularly as urbanization increases within the sub-basin as a whole.[88]

Fish species are similar to those in the Bow River, with the Elbow River providing important habitat for mountain whitefish and brook, brown, rainbow, cutthroat, and bull trout. Burbot, yellow perch, lake chub, longnose dace and mountain, longnose and white sucker are also likely within the lower Elbow River and Glenmore Reservoir. Deeper pools and oxbows provide overwintering areas, while the Weaselhead wetlands are important rearing habitat.[88]

The upper Elbow River flows through Kananaskis Country, which is a popular recreational destination. A variety of recreational activities occur within this sub-basin including camping, hiking, equestrian activities, mountain biking, off-highway vehicle use, fishing and kayaking.[222] Commercial land uses within the sub-basin include logging, ranching and gas field development. Through the middle section of the sub-basin, agricultural use includes forage crops, ranching and dairy farms. Once the river enters Calgary, it flows past a series of natural environment and manicured parks, as well as residential and commercial areas.

The Elbow River valley has an ever-increasing amount of country residential development. Potable water for these communities, from the Bragg Creek area to the Calgary city limits, comes from individual wells or small water co-operatives. The developments employ a variety of sewage treatment systems including individual septic or sewage pump-outs and sewage lagoons.[124]

Water quality in the Elbow River has been deteriorating in recent years, with concentrations of dissolved phosphorus, turbidity and fecal coliform bacteria all increasing.[218] These water quality concerns prompted a recent four-year study of the Elbow River above the Glenmore Reservoir. Though specific sources

The Weaselhead, Elbow River – K.Richardson

of nutrients within the sub-basin were difficult to determine, sources of bacteria were found to include either wild or domestic animals, but not human wastewaters.[222]

The Glenmore Dam was constructed in the early 1930s. The reservoir it formed covers an area of 388 ha. The dam is used secondarily for flood protection for the lower reach of the Elbow River, but primarily as one of the two sources of municipal water for Calgary. Water quality is consistent throughout the reservoir, and generally has low turbidity, moderate ionic concentrations and is well oxygenated. The water column is generally well mixed and unlike some reservoirs, no thermal stratification occurs. Rooted aquatic plants are abundant throughout the littoral zone of the reservoir. These plants also provide a substrate for dense algal growth and clumps of algae can be observed floating in the water. The algae within the reservoir are species common to hard-water lakes, and are not known to produce taste or odour problems in drinking water. Approximately 10 stormwater outfalls discharge into the reservoir. However, they do not

The Nose Creek Watershed Partnership

Airdrie, Calgary and the Municipal District of Rocky View took a co-operative approach to addressing water quality issues in 1998, forming the Nose Creek Watershed Partnership. The partnership has since expanded to include the Town of Crossfield, Ducks Unlimited Canada, and the Calgary Airport Authority. Stakeholders, community groups and concerned citizens have joined together to learn about the importance of the watershed, riparian areas and the aquatic ecosystem. This partnership hopes to improve the water quality of the watershed through identifying sources of contamination and initiating clean-up efforts and stewardship measures with all stakeholders. They have developed a Watershed Health Report and are in the process of developing the Nose Creek Water Management Plan, which is a multi-phase approach to sustainable water management. The Plan will link the issues of water quality, water quantity, riparian habitat and aquatic species with the watershed's economic and social priorities. Recommendations will guide the community's future activities. Public input is generated through open houses, stakeholder meetings and web surveys.

West Nose Creek - BRBC

appear to contribute to bacterial concentrations. While total coliform levels can be high, fecal coliforms and *E. coli* numbers are generally very low, indicating minor contamination from mammalian wastes.[100]

The stormwater discharged from Calgary into the Glenmore Reservoir and lower Elbow River is generally untreated. Studies during the 1990s indicated little hydrocarbon, nutrient or metal pollution during baseflows. Although chlorine levels were low, detectable levels at all outfalls along the lower Elbow River indicated the presence of treated city water, either from leakage of the distribution system or from residential irrigation. Bacterial concentrations in the stormwater varied greatly, but no leakage from the wastewater system was evident.[102] Calgary is in the process of installing stormwater infrastructure upgrades to improve the quality of stormwater entering the Elbow River. Since the early 1990s, all new developments discharging into the upper Elbow River have been required to incorporate wet ponds and/or wetlands to improve stormwater quality.

Nose Creek

Nose Creek flows south from Crossfield, passing though Airdrie and northern Calgary before joining the Bow River just upstream of the WID weir at the lower extent of Reach 4. The sub-basin is 979 km^2 in size and 73 km in length. Its main tributary is West Nose Creek.

The flat topography of this sub-basin varies little, with the exception of the escarpment bluffs above the creek that range from 10 to 45 m in height. The creek meanders between these bluffs along a broad floodplain that is up to 670 m wide.[94] The watershed of Nose Creek is located in the parkland and grassland sub-regions. However, the majority of the natural vegetation communities have been replaced with pasture, cropland and urban landscapes. The landbase of the northern and western portions of the Nose Creek sub-basin are primarily agricultural, while the lower reaches have been channelized as they flow through the urban landscape of Calgary.

The Nose Creek watershed and its river valleys still provide important wildlife habitat, including wildlife corridors and a connection to natural areas that are otherwise separated by agricultural or urban development.[63] However, increasing urban and industrial development in close proximity to Nose Creek and West Nose Creek is compromising these functions.

Mammals within the watershed include coyote, mule deer, white-tailed deer, Richardson's ground squirrel, white-tailed hare, red fox, badger, meadow vole, and long-tailed weasel.[107] Bird species include resident ring-necked pheasant, gray partridge and black-capped chickadee.

Migrant bird species that are present in spring and fall may include the yellow-rumped warbler, Sprague's pipit, Baird's sparrow and red-tailed hawk.[107] Within Alberta, Sprague's pipit and Baird's sparrow are listed as "sensitive" (see Chapter 2).

In 2000, the Cows and Fish program assessed the riparian health of the agricultural and urban areas of Nose Creek and West Nose Creek as healthy, but with problems.[94] These problems included channel incisement, altered stream banks and invasive weed species such as Canada thistle and perennial sow thistle. Human disturbances included pathways and structural alteration of the stream banks such as armouring of meander bends. Most of the natural riparian vegetation


Yellow-headed Blackbird – K.Richardson


Red-Winged Blackbird – K.Richardson


Yellow Warbler – A.MacKeigan

has been disturbed and the floodplain is heavily grazed.

Water quality data collected from 1999 to 2001 rated Nose Creek as poor.[175] Nutrients, bacteria, total dissolved solids, metals and pesticides all exceeded water quality guidelines. Dissolved oxygen concentrations were occasionally low. Guidelines for the protection of aquatic life were exceeded by nutrient and metal concentrations; total dissolved solids and pesticides exceeded agricultural use guidelines.

Bacterial concentrations exceeded recreational guidelines,[175] indicating that swimmers could face risks for skin, eye or ear irritations if in direct contact with Nose Creek waters. Trends over time indicate both improvements and declines in water quality variables. Concentrations of nitrate and total coliform bacteria are improving, while biochemical oxygen demand and total suspended solids concentrations are getting worse.[158]

Fish species found in Nose Creek include white sucker, longnose sucker, longnose dace, fathead minnow, lake chub, and brook stickleback.[175] The poor water quality of Nose Creek may negatively impact fish habitat. Increased sedimentation, decreased oxygen concentrations and the proliferation of algae can all cause problems for aquatic life.

The watershed health problems within Nose Creek can be linked to the alteration of the watershed and its use for agriculture and residential development. As residential and industrial development is projected to increase in the Nose Creek sub-basin during the next few decades, efforts to reduce impacts on water quality are ongoing. The Town of Crossfield uses a lagoon system to treat wastewater. During the summer months, an effluent irrigation program reduces the volume of wastewater discharged to Nose Creek.

Wastewater from the City of Airdrie is pumped to Calgary where it is treated at the Bonnybrook WWTP and discharged into the Bow River in Reach 5. There is a proposal for Crossfield to connect to Calgary's WWTPs in the future.

6.6 Where are we Headed?

Reach 4 of the Bow River was not specifically included in the original Terms of Reference for Phase 2 of the South Saskatchewan River Basin's Water Management Plan (see Chapter 2). However, the Bow Basin Advisory Committee provided recommendations for this reach.[51] As a result, it is anticipated that the SSRB WMP will be recommending Water Conservation Objectives for Reach 4. There are currently Instream Objectives for this reach calculated in 1994 using the Fish Rule Curve.[126] Releases from the Bearspaw Dam generally satisfy these Instream Objectives and meet the water requirements for downstream licences.[104 152]

Conservation efforts have allowed total municipal use to remain approximately the same for 25 years, and the City of Calgary has a strategic plan in place to maintain this trend. The city is taking a broad based approach to demand management, which will be implemented as required. The city's goal is to accommodate growth while ensuring that the total amount of water withdrawn remains unchanged by reducing per capita use.[114]

The greatest demand for municipal water occurs during hot dry summers, for lawn, garden and tree watering. Because this is also the time when the Bow River flows are lower, conservation rates must match growth rates. There are limited opportunities for future allocations from the Bow River. In the future, water is likely to become available only as the result of

Urban development along the Elbow River – K.Richardson

conservation and allocation transfers within the basin.

It is expected that the population and landbase for residential development will continue to expand, while agricultural use will decline. Growth in industrial and commercial development is also expected to be high in and around Calgary. Water quality has the potential to decline as the population grows and as more water is withdrawn from the rivers. However, Calgary will soon operate under a new provincial approval for stormwater discharge, under which the stormwater system will be required to comply with limits for nutrient loading and total suspended solids. Further improvements to the quality of stormwater discharged to the Bow River are therefore expected.

The stringent treatment requirements at the water treatment plants, particularly the need to remove protozoans such as *Giardia* and *Cryptosporidium*, are a consequence of contamination of the watershed upstream of the Bearspaw and Glenmore dams. The high cost of treating water to ensure that it is safe for public use requires serious consideration of watershed protection measures. The management of the Bow and Elbow river watersheds is critical to Calgary's water supply in terms of quality, total quantity and availability of seasonal flows.

Calgary and its upstream neighbours are beginning to cooperate with regard to watershed protection. Coordinating the treatment and monitoring of effluent discharges, as part of the expanded regional wastewater servicing agreements with high growth communities surrounding Calgary (Cochrane, Chestermere, Airdrie, and the Tsuu T'ina), is one component in the protection of the watershed.

Due to the already high and increasing pressures on water resources within Reach 4, it is important to collect comprehensive information on which to base predictions and make management decisions. Water quantity is currently measured at two sites within this reach. Impacts from stormwater effluents on water quality are being studied, with limits on total pollutant loadings soon to be established. The water treatment plants and industries also monitor the quality of water they discharge to the Bow River. Water quality monitoring programs also exist for the Elbow River and Nose Creek sub-basins. These monitoring programs provide an excellent basis of data on the status of water quantity and quality in this reach.

However, water quality information is lacking for the Bow River, with no long-term water quality monitoring station located within this reach. Despite the intensity of development, impacts from land use and other non-point sources of pollutants on water quality and quantity of the Bow River have not been well defined. These data gaps represent opportunities to improve the understanding and management of the Bow River within Reach 4.

Chapter 7

Pelicans at WID Weir – K.Richardson

Chapter 7

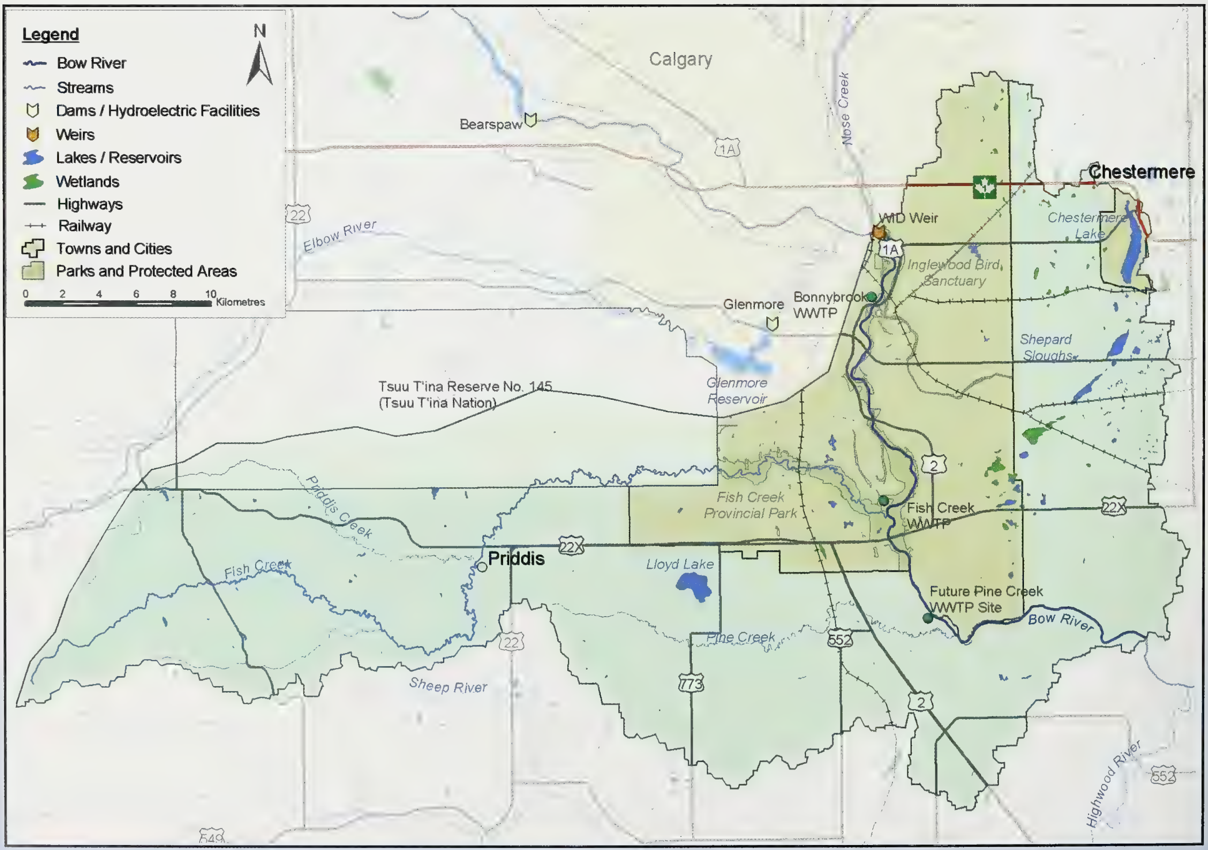
Reach 5 – Western Irrigation District Weir to Upstream of the Highwood River Confluence

7.1 What is in this Reach?

Reach 5 of the Bow River flows from the Western Irrigation District (WID) weir, south through the City of Calgary and ends approximately 4 kilometres (km) upstream of the confluence with the Highwood River. A large portion of the mainstem of the Bow River flows within the urban and industrial area of Calgary. The length of the river in this reach is 42 km; the drainage basin is 1,137 square kilometres (km^2) (Figure 7.1).

Fish Creek is the major tributary and enters the Bow River approximately mid-reach. The Fish Creek sub-basin originates in the foothills of Kananaskis Country and comprises the western portion of the reach. The creek flows through the M.D. of Foothills and the Tsuu T'ina Reserve No. 145 (home of the Tsuu T'ina Nation) prior to entering the City of Calgary. The lower section of Pine Creek, which flows from the west into the Bow River at the southern extent of the reach, has been channelized and now flows through a culvert. Other small tributaries that once drained directly into the Bow River have been captured in the city's stormwater system. The eastern portion of the landbase drains a primarily agricultural region, with some residential use, including Chestermere and the Municipal District of Rocky View.

Figure 7.1 Overview of Reach 5[39 45 75]



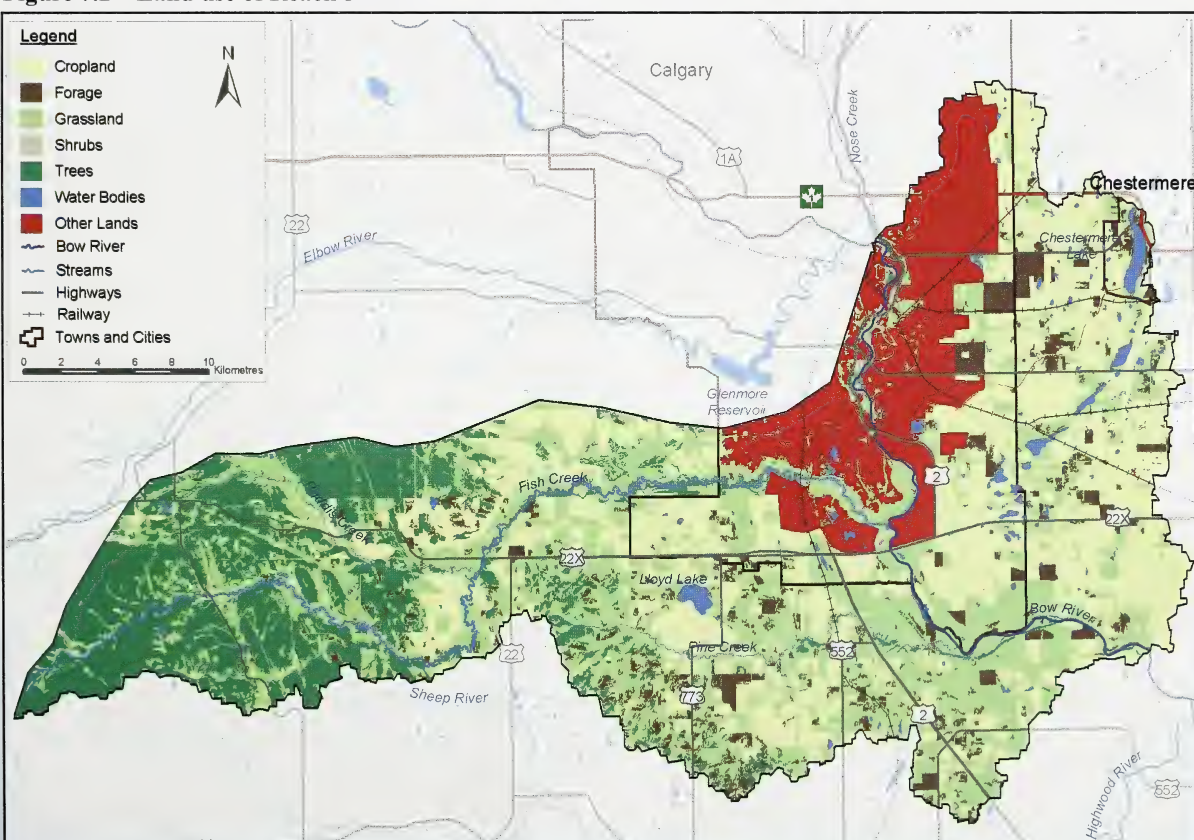
Like Reach 4, Reach 5 drains a landscape that includes mountains, foothills, parkland, and prairie. Natural sub-regions include the sub-alpine, montane, foothills parkland, and foothills fescue. Parks and protected areas include Fish Creek Provincial Park and several Natural Environment Parks along the Bow River within the City of Calgary. Approximately 12.3% of the land has some kind of park status.

Chestermere Lake, a reservoir created as part of the WID system, is the largest lake, at 226 hectares (ha), and provides habitat for resident and migratory birds. Several wetlands are also found, including the Shepard Sloughs. The valleys of the Bow River and Fish Creek are important wildlife corridors and refuges within this increasingly developed landscape. Mammals and birds characteristic of both mountain and prairie ecosystems can be found. Since agricultural and urban development began, many of the wetlands have been lost. The river valleys, wildlife habitat and riparian areas of the Bow River and Fish Creek have also been impacted by agriculture and urban and country residential development.

Downstream of Calgary, the Bow River is considered a world-class fishery, particularly for the introduced rainbow and brown trout. Mountain whitefish are also a common species within this reach. Within the city limits, the negative impacts of urban development on fish habitat have been partially offset by the wastewater effluent discharged from Calgary's wastewater treatment plants (WWTPs). The nutrient-rich effluent stimulates aquatic growth and enhances fish production. Increased winter flows, a result of upstream hydroelectric facilities, also provide benefits to fish habitat within this reach.

Like Reach 4, urban and adjacent country residential developments are a major human use of the land along the mainstem of the Bow River (Figure 7.2). The urban footprint takes up 314 km^2, or 24.7% of the landbase. In 2003, Calgary covered an area of 725 km^2, of which 42% lies within the landbase of Reach 5. Outside the City of Calgary, agriculture is the dominant human land use, with 361 km^2 (31.7%) of the landbase used for grazing and crops. Several major highways, including the TransCanada Highway and Highways 1A, 22 and

Figure 7.2 Land use of Reach 5[6 39 45]



22X, criss-cross the landbase, as does the Canadian Pacific Railway.

Reach 5 (along with Reach 4) is one of the most highly populated in the Bow River Basin. Significant growth has occurred in the past few decades, with the population of Calgary increasing from 710,000 in 1991 to 922,000 in 2003.[36] Long-term forecasts estimate Calgary's population will be between 1.15 and 1.5 million by 2026.[80] The Town of Chestermere has increased from 918 in 1991 to 5,712 in 2003.[224] Country residential populations along the western and eastern extents have also increased over the past decade. These smaller communities and the Tsuu T'ina Nation brought the total population that is outside the City of Calgary proper to approximately 10,902 in 2001.[36] The urban and rural residential population is expected to increase in the future, while agricultural use is projected to decrease.

In addition to the ongoing influence of upstream hydroelectric facilities, a major impact on flows of the Bow River within this reach is the withdrawals at the WID Weir. As with all irrigation districts, the WID provides water seasonally for crop irrigation, recreation, livestock watering, and municipal and domestic drinking water supply. While the WID withdraws water from the Bow River in Reach 5, most of the district and municipalities it services are located in Reach 7 and are therefore discussed in Chapter 9.

As discussed in Chapter 6, the City of Calgary withdraws its municipal water from the Bow and Elbow rivers in Reach 4. Calgary provides municipal water to Chestermere. Strathmore and several country residential communities withdraw water from the Bow River and groundwater sources in Reach 5. The Tsuu T'ina Reserve withdraws groundwater and water from the Elbow River in Reach 4. Calgary's two wastewater treatment plants (WWTPs) discharge to the Bow River within Reach 5. Calgary treats municipal wastewater from Cochrane, Airdrie, Chestermere, and the Tsuu T'ina, all of which is discharged to the Bow River in this reach. Other communities treat their wastewater in lagoons or septic fields. Stormwater discharges from the city also influence water quality of the Bow River within this reach.

This densely populated area receives a high level of tourism and recreational use, particularly along parks and pathways of the Bow River and Fish Creek valleys. Its international reputation for excellent fishing opportunities leads to heavy use by anglers on the Bow River. Kayakers, rafters, and canoeists also use the river. Chestermere Lake is used for swimming, sailing, windsurfing, water skiing, and fishing. Given the high number of recreational opportunities and proximity to growing urban centres, increased levels of tourism and recreational use can be expected in the future.

Bicycling on the Bow River Pathway – K.Richardson

7.2 Hydrology

The natural flows and seasonal pattern of the Bow River in Reach 5 are illustrated in Figure 7.3, which shows the average discharge of the *Bow River at the WID Weir*. There is no flow gauging station in Reach 5, but the approximate flows at this location have been calculated from the addition of flows from the Water Survey of Canada stations *Bow River at Calgary* AB05BH004 and *Elbow River below Glenmore Dam* AB05BJ001 (Figure 7.4, page 118).

The natural stream flows of the Bow River at the WID weir peak during the spring and summer, averaging about 290 cubic metres per second (m^3/s). Groundwater that is recharged from the foothills forests and prairie wetlands provides the majority of the natural baseflow during the winter;[76] it averages just below 30 m^3/s.

The average recorded (estimated) flows at the *Bow River at WID Weir* (Figure 7.3) show the modified flow regime that results from upstream hydroelectric dams, as well as water withdrawals within the reach, including those of the WID. The average recorded spring discharge is lower than the natural and peaks at about 210 m^3/s.

In contrast, baseflows increased to an average of just under 55 m^3/s. Minimum winter flows through Calgary are now almost double what they would be naturally. This change benefits municipalities and industries and their ability to meet water demands and effluent release guidelines.[115]

How do Water Withdrawals Affect Hydrology?

Table 7.1 outlines the water licence allocations for the Bow River in Reach 5 for 2002. Reach 5 marks the beginning of substantial water allocations and withdrawals for irrigation purposes. While dams are the predominant influence on the flows in Reaches 1 to 4, irrigation withdrawals also influence the flows in Reach 5 and the reaches downstream of Calgary.[90] The total volume of water licensed for withdrawal by all users within this reach was over 211 million cubic metres (m^3) in 2002. These withdrawals represent approximately 6.6% of the average annual flow of the *Bow River at the WID Weir*.

The majority (94%) of the total allocation is licensed for irrigation/agricultural use. The WID is by far the largest licensee within this reach, and in 2002 was allocated over 197 million m^3. Although 99% of the irrigation/agriculture allocation is withdrawn from the WID headworks at the upper end of this reach, more

Table 7.1 Licensed allocation of the Bow River in Reach 5 (2002)[108 193]

Water User	Annual Licensed Allocation (m^3)	Percentage of Annual Average Natural Discharge (%)[a]
Industrial	5,398,160	0.17
Irrigation & Agriculture	199,396,245	6.21
Municipal	2,484,560	0.08
Other	4,026,414	0.12
Total	**211,305,379**	**6.58**

[a] Average annual natural discharge of Bow River at the WID Weir is 3,210,966,900 m^3 (1912-2001)

Figure 7.3 Discharge of the Bow River at the WID Weir (1971 – 2001)[29]

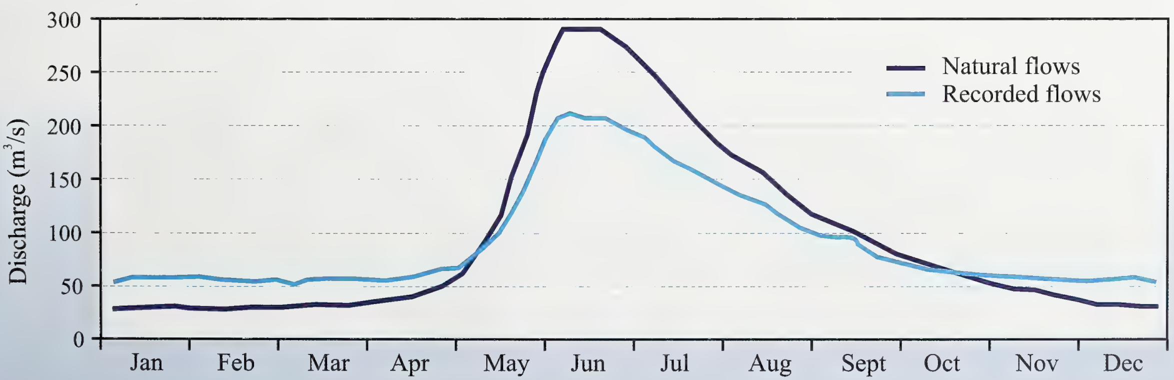


Table 7.2 Licensed and estimated annual consumption and return flows to the Bow River in Reach 5 (2002)[193]

Water User	Annual Consumption from the Bow River (m^3)		Annual Return Flows to the Bow River (m^3)	
	Licensed	Estimated[a]	Licensed	Estimated[a]
Industrial	4,500,180	1,369,987	897,980	651,280
Irrigation & Agriculture	145,976,614	137,424,888	53,419,631	48,234,073
Municipal	1,220,242	438,748	1,264,318	1,217,161
Other	2,802,798	2,618,725	1,223,616	51,806
Total	**154,499,834**	**141,852,348**	**56,805,545**	**50,154,320**

[a] When water use reports for each license are absent, the licensed consumption and licensed return flows are used to approximate the estimated consumption and return flows, respectively. This likely overestimates the estimated consumption and return flow data in this reach

than a dozen private licenses are also allocated water for feedlots, stockwatering and crop production. While its withdrawals are primarily for agricultural purposes, the WID canal and reservoir system also serves as the municipal water source for several small communities that are outside Reach 5. Water is also needed in the canals and off-stream reservoirs to facilitate delivery to irrigation turnouts and maintain water levels in the system.

Industrial, municipal and "other" allocations within Reach 5 are minimal, each amounting to less than 1% of the average annual flow of the Bow River. Industrial water users of the Bow River within this reach include quarries, greenhouses and oilfield injection. The "other" category consists primarily of water use by golf courses and urban parks. Municipal use in this reach includes several small co-operatives. The portion of the City of Calgary that is within this reach is serviced by water withdrawals from Reach 4 (see Chapter 6).

Although located outside Reach 5, several small communities, including Strathmore, Standard, Langdon, Gleichen, and Rockyford, are included in the municipal licenses in Table 7.1. These communities fill their municipal reservoirs with water from the WID canal system during the irrigation season (May to September) in anticipation of the canal system shutdown during the rest of the year. While the water for these communities is carried by the WID canal system, their use is calculated separately from the WID allocation.

Table 7.2 outlines the annual licensed consumption and return flows for Reach 5. For the municipal users within this reach, most of the water is used, treated, and then returned to the river. Some of the municipal return flows from the cooperatives are returned to Calgary's wastewater treatment plants, which discharge to the Bow River in this reach. It is important to note that Table 7.2 does not include the wastewater discharged from Calgary's WWTPs, as these return flow values are included in the municipal licence information in Chapter 6. Smaller rural communities within Reach 5 use lagoons and septic tanks for wastewater treatment and do not discharge directly to the Bow River.

The actual amount of water consumed by the WID varies annually and depends primarily on weather conditions. In 2002, the WID withdrew 95% of their total allocation. In hotter, drier summers, the WID may withdraw 100% of its licensed allocation, while in years with more summer precipitation as little as 50% of the allocation may be withdrawn.[247] In the past, a greater proportion of the WID withdrawals were made during spring, when the river was high, and stored off-stream in Chestermere Lake and the Langdon Reservoir.

In recent years, however, storage in Chestermere Lake has become negligible due to an agreement with Chestermere to stabilize lake levels during the summer (see sidebar, page 117). Thus, more water is withdrawn directly from the Bow River during June and July, when crops are growing. In August, when the river is lowest, the need for water is reduced.[243]

The WID returns some of the water withdrawn via return flows at the end of the irrigation canal system. The return flows vary greatly from year to year; with the amount dependent largely on precipitation. From 1997 to 2000, return flows for the WID were estimated at an average of 56% of consumption.[141] A lower percentage of water is returned to the river in dry years; return flows for 2001 and 2002 were around 22%. During wet years, higher precipitation reduces irrigation demands, but the canals have to remain full for those who wish to irrigate.

The WID Conveyance System

The WID conveyance system consists of a series of canals and reservoirs that irrigate the district and provide an outlet for urban stormwater. The system consists of over 1,200 km of canals and an increasing proportion of buried pipeline, which reduces evaporative and operational spill losses. Withdrawing water from the Bow River at the WID Headworks at the top of Reach 5, the water flows via the Western Headworks Canal, a provincially owned headworks, through the City of Calgary to Chestermere Lake. Chestermere Lake is owned by the WID, and is the start of its system. Two canals exit Chestermere Lake, with the southeast canal carrying slightly more flows (60%) than the northeast canal. The southeast Secondary A canal flows into the Langdon Reservoir, which is the WID's main storage reservoir. From the Langdon Reservoir, a series of canals irrigate lands to the east, including those around Carseland, Strathmore, Gleichen, and Cluny. These eventually drain into Crowfoot Creek; return flows drain to the Bow River in Reach 7.

The northeast canal that exits Chestermere Lake splits into the Secondary B and C canals. The Secondary B canal services Standard and nearby areas. Its drainage splits between Crowfoot Creek and Serviceberry Creek. The Secondary C canal provides water for lands farther to the north, including Rockyford, and is eventually diverted to Serviceberry Creek and the Rosebud River. Serviceberry Creek and the Rosebud River both drain into the Red Deer River Basin. However, both the Red Deer and the Bow River ultimately converge downstream at the South Saskatchewan River.[243]

Western Headworks Canal to Chestermere Lake – K.Richardson

The return flow channels carry precipitation runoff, unused irrigation water from both the canal system and on-farm operations and, to a minor extent, subsurface drain effluent from the agricultural lands. Return flow channels drain all lands, whether they are irrigated or not. The majority of the flows return by way of Crowfoot Creek to the Bow River near the end of Reach 7. Some of these flows are diverted to the Red Deer River Basin.

How does Land Use Affect Hydrology?

Approximately 544 km^2 (42.3%) of the landbase has been cleared or changed from its natural vegetation. The urban landscape of Calgary is the greatest land use along the mainstem of the Bow River, but agriculture, resource extraction, and country residential land uses have substantial impacts on the Fish Creek sub-basin and the eastern portion.

The majority of the land that drains directly into the mainstem of the Bow River in Reach 5 is within Calgary's city limits. The urban landscape produces significantly higher stormwater runoff volumes relative to those generated from the prairie ecosystems they replace. See Chapters 2 and 6 for a discussion of impacts of urban stormwater runoff on flows of the Bow River.

Approximately 31.7% of the landbase has been cleared for agriculture and is used primarily for grazing and growing forages and cereals. Livestock includes cattle, chickens, pigs, sheep, horses and bison. It is predicted that intensive livestock operations will increase in the future.[137] However, the level of grazing and agriculture will probably remain low compared to downstream portions of the Bow River Basin.

There is no site-specific data on the impacts of these land-use practices on the water quantity of the Bow River or its sub-basins. As mentioned, although the WID withdraws water from Reach 5, it does not irrigate the crops within the landbase of this reach. (See Chapter 9 for a discussion of the WID and agriculture.)

Pine Creek Wastewater Treatment Plant

Continued growth within the City of Calgary (and in three of the neighbouring communities, Cochrane, Airdrie, and Chestermere, that convey their wastewater via pipeline to Calgary) has generated an increase in wastewater flows and loads. These growth trends appear to be continuing and have prompted the need for a third WWTP. The Pine Creek WWTP will be constructed to accommodate these immediate and long-term wastewater treatment needs in an efficient and environmentally responsible manner.

The plant will be located south of the current city limits, just north of the confluence of the Bow River and Pine Creek. Construction began in late 2004, with completion of the first phase projected for 2007. Like Calgary's Bonnybrook WWTP, the Pine Creek plant will use biological nutrient removal processes and UV disinfection in order to enhance wastewater quality and minimize the use of chemicals. Because of its location beside the Bow River, the plant will treat all its stormwater runoff, use native plants in its landscaping and protect the riparian area. The Pine Creek WWTP will also feature wetland developments, a public Water Education Centre and University of Calgary research facilities. Expansion of the plant is included in the design to provide for future growth, with an ultimate capacity of 700 Megalitres (ML) per day planned for 2060.

Bow Isles looking upstream (near Pine Creek) – M.Hickley

7.3 Water Quality

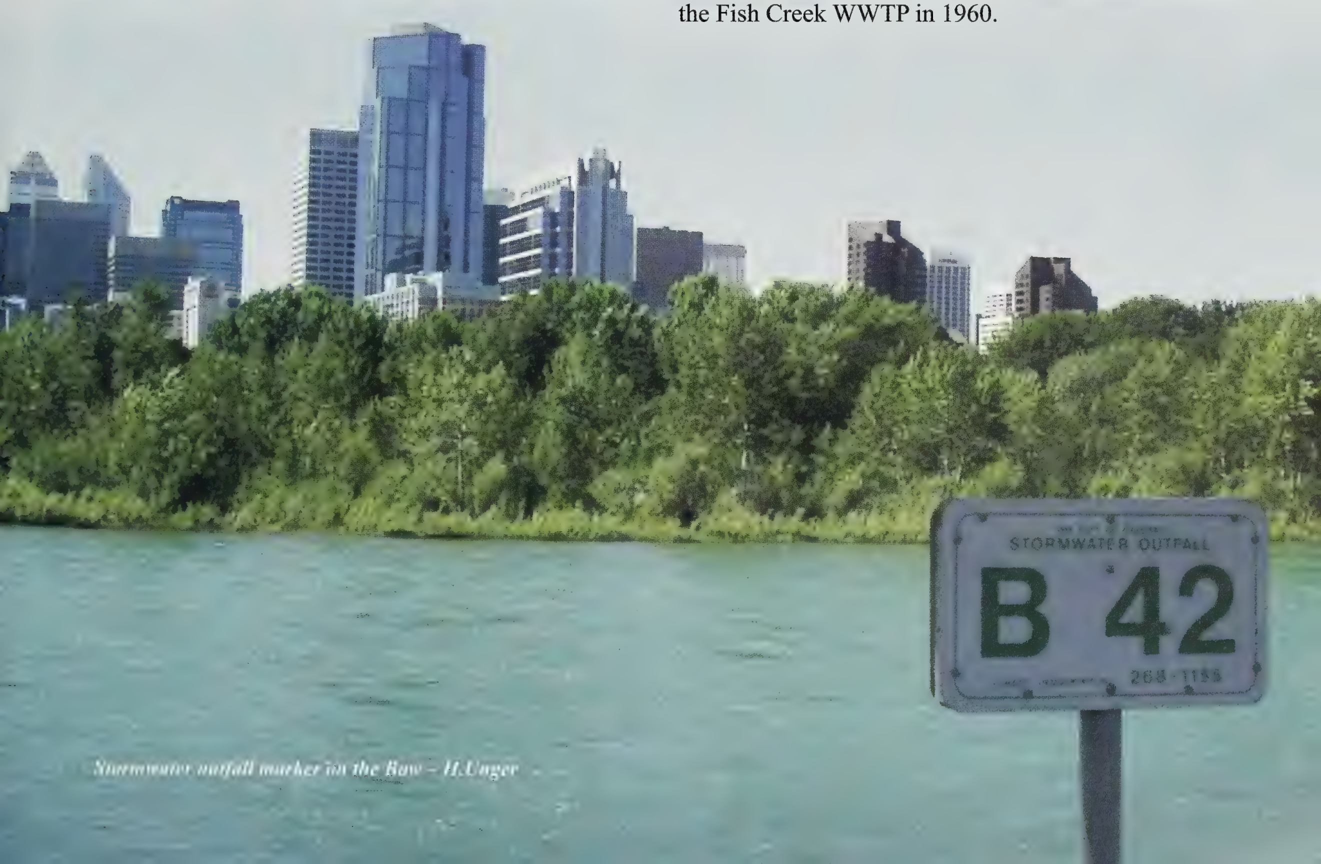
No recent water quality data exists for Reach 5 of the Bow River. Though Alberta Environment has monitored water quality for several studies and synoptic surveys during the 1990s, long-term data necessary for producing a Water Quality Index for this reach are not available. However, substantial information is available for *Bow River at Stier's Ranch* (AENV Station 00AL05BM1100) (Figure 7.4, page 118). This station is located near the City of Calgary limits, about 10 km upstream of the end of this reach. Water has been sampled here since 1992, however, a decreased sampling frequency and a limited number of variables over the last few years have prevented the generation of a WQI. The Stier's Ranch data and information from other sources have been used to describe the water quality and its major influences in this reach.

Upstream of the Bonnybrook and Fish Creek WWTP effluents, the water quality in Reach 5 can be considered similar to that in Reach 4 (see Chapter 6). The upstream section of this reach receives effluent from many stormwater outfalls within the City of Calgary, as well as inputs from Nose Creek and the Elbow River. Stormwater is a major contributor of sediment, road salt, hydrocarbons, pesticides, metals, nutrients, and bacteria to receiving waters. Withdrawals at the WID weir can periodically influence water quality in this reach by reducing the assimilation capacity of the river.

Downstream of Calgary's WWTPs, the water quality of the Bow River has been significantly impacted. In order to get an accurate representation of water quality, it is important to measure below the mixing zone, where the effluent plume has completely mixed with the river. The *Bow River at Stier's Ranch* site is located just downstream of the mixing zone for the Fish Creek WWTP. However, once the planned Pine Creek WWTP is operational, a new station on the Bow River will be required farther downstream to capture these impacts.[215]

Calgary has made great improvements in the quality of the effluent discharged by its WWTPs over the last century. Due to concerns about the discharge of raw wastewater into the Bow River, the Bonnybrook WWTP was constructed in 1932, but the technology of the day was only capable of primary treatment.

Records of poor water quality in the Bow River, including nuisance algal growth, high bacteria counts and oily tasting fish, date back to the early 1940s. These problems were partially alleviated following upgrades to the Bonnybrook WWTP in 1954 and construction of the Fish Creek WWTP in 1960.



Stormwater outfall marker on the Bow – H.Unger

Construction of the Bearspaw Dam in 1954 increased minimum flows during the winter, which also improved water quality. However, increasing population growth and wastewater discharges eventually led to low oxygen concentrations and high nutrient concentrations in the Bow River during the 1960s and 1970s.[133] Today, the Bonnybrook plant has a capacity of 500 ML/day; the Fish Creek plant is smaller, treating 73 ML/day.

Several upgrades have since been made to Calgary's WWTPs (1982, 1987, 1990, 1999), which have greatly reduced suspended solids, organic material, bacteria, and nutrient loading.[73 203 216] Both WWTPs have installed full tertiary treatment (see Chapter 2). The Bonnybrook WWTP uses mainly biological nutrient removal processes, while the smaller Fish Creek WWTP still uses chemical precipitation. Both plants use UV light rather than chlorine for disinfection. Sludge from the plants is treated at the Shepard Sludge Lagoons and is then used on fields as an organic fertilizer and soil conditioner, in accordance with provincial guidelines.

In 2004, Calgary's leadership in wastewater treatment was recognised by the Sierra Legal Defence Fund with an A+ rating. This was an improvement from its A rating in 1999. In both years, Calgary was the highest rated city in Canada.[212]

Regardless of these improvements, Calgary's WWTPs are the greatest contributors of nutrients (including total phosphorus, total ammonia and nitrate) throughout the Bow River Basin.[249] Nutrient levels at the *Bow River at Stier's Ranch* site are elevated compared to upstream and downstream locations. These nutrients stimulate aquatic plant growth, which can reach nuisance levels and lead to decreased oxygen concentrations.

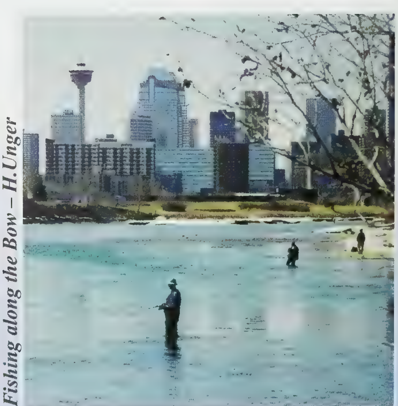
Recent monitoring has shown that in the late summer, when aquatic plant growth is at its peak, dissolved oxygen concentrations in this reach of the Bow River can drop to low levels during the night.[121 122] While plants generate oxygen through photosynthesis during the day, they respire during the night, and can consume large amounts of oxygen. The decomposition of large amounts of this plant material, as well as the organic material released in the WWTP effluents, also consumes oxygen. Because of its influence on productivity, total phosphorus is the primary focus for management by the city.[77] Although stormwater also contributes to phosphorus loading to the Bow River, approximately 86% of Calgary's phosphorus loading comes from its wastewater effluents.[79]

Calgary's current approval to operate its wastewater system is in effect from January 1996 until November 2005. Under this approval, the city is required to plan, design, construct, and manage the operation of the wastewater system (and stormwater system, as discussed in Chapter 6) to comply with total loading limits for several water quality parameters. A proposal by the City of Calgary currently under review by Alberta Environment recommends that future wastewater management should focus on total phosphorus and total ammonia, and recommends maximum daily values for the two WWTPs.[77] In order to meet or exceed these recommended targets, Calgary has planned upgrades that will further improve the effluent quality discharged by the WWTPs. These upgrades have positive implications for water quality of the Bow River within this reach, as well as in downstream reaches.

Treated wastewaters from urban centres can also contribute trace amounts of prescription and non-prescription drugs to the river. These chemicals are not covered by water quality guidelines and little is known about their effects on the environment and human health. As of February 2005, a study on pharmaceutical drugs discharged from Calgary's WWTPs to the Bow River was being finalized (see Chapter 2).

Geese on the Bow – H.Unger

Riverbank Golf Course – H.Unger



Fishing along the Bow – H.Unger

Water quality of Chestermere Lake

Chestermere Lake was known as Kinniburgh Slough until 1903, when the intermittent lake was dammed to create the reservoir for the Canadian Pacific Railway irrigation project. The lake was originally designed to act as a balancing pool and a source for any increased demand within the irrigation system, providing 261 ha of off-stream storage. In 1944, the WID was formed and took over operation of the CPR's irrigation system, including Chestermere Lake. In addition to its function as one of the WID reservoirs, the lake is an important recreational area. Rapid residential development around the lake has grown into the Town of Chestermere, which totalled 5,712 people in 2003. In recent years, water levels have been stabilized to meet the aesthetic needs of the town of Chestermere, reducing the active storage capacity that is available for irrigation. During times of drought, with adequate notice to the town, water can be withdrawn for irrigation and the lake levels lowered. The storage in Chestermere Lake can meet the irrigation needs of the WID for only three days.

Water quality and aquatic weed growth in the lake have led to concerns from both recreational and irrigation users regarding source water quality. Concerns have generally centred on stormwater quality from City of Calgary outfalls that discharge into the canals prior to entering the lake. Nose Creek (see Chapter 6), which enters the Bow River just upstream of the Western Headworks Canal, has also been viewed as a contributor to deteriorating water quality in the lake. The City of Calgary is working to improve its stormwater quality, and the diversion of water from the WID canal to the Shepard Wetland Diversion treatment facility will likely further improve source water quality to Chestermere Lake.

While there have been problems with erosion and weed growth within canal outlets from the lake, in general, studies have found the water quality of the lake is relatively good. Low levels of bacteria, nutrients and total suspended solids have been measured, with elevated concentrations following upstream storm events. However, the lake does have elevated concentrations of some metals that exceed water quality guidelines for irrigation and the protection of freshwater aquatic life. The lake has also been accumulating sediments (and by association, nutrients and metals) since it was constructed. In order to remove accumulated sediments and reduce weed growth, dredging of the lake has been proposed. However, there are concerns that dredging may release phosphorus from the sediments into the water, with the potential to impair water quality and stimulate additional aquatic plant growth.[112]

Chestermere Lake – R.Wolfe

7.4 Ecosystems

Terrestrial Habitat

A diverse range of ecosystems and wildlife habitat is found within the landbase of Reach 7. The landscape changes from the Rocky Mountain region in the west, to the parkland region in the central portion, to the grassland region in the east. Natural sub-regions include sub-alpine, montane, foothills parkland, and foothills fescue ecosystems (Table 7.3 and Figure 7.4).[19]

Within this reach, the mainstem of the Bow River is located entirely within the foothills fescue sub-region. However, the majority of the river flows inside the urban environment of Calgary and as a result, much of the mainstem's natural vegetation and wildlife habitat has been eliminated. Approximately 39.8% of the Fish Creek sub-basin is also located within the city or other rural residential developments and includes several natural regions with relatively healthy vegetation communities and wildlife habitat.

The upper elevations contain the sub-alpine and montane sub-regions; downstream there is a transition to the foothills parkland sub-region and the foothills fescue sub-region. The vegetation and wildlife characteristics of the sub-alpine sub-region are described in Chapter 3, while those of the montane sub-region are described in Chapter 4.

The foothills parkland sub-region is described in Chapter 6, and is a transitional area between the montane forests and foothills fescue grasslands.[19] Much of this natural sub-region is located on the developed lands of the City of Calgary. As a result, the natural vegetation has been eliminated and replaced by urban developments and manicured parks. The most common trees within Calgary now are trembling aspen, balsam poplar, white spruce, Colorado spruce, and cottonwood.[84] The Tsuu T'ina Nation is also located within this sub-region, and like other aboriginal lands in

Figure 7.4 Natural sub-regions and measuring locations of Reach 5[23 39 40 45 195]

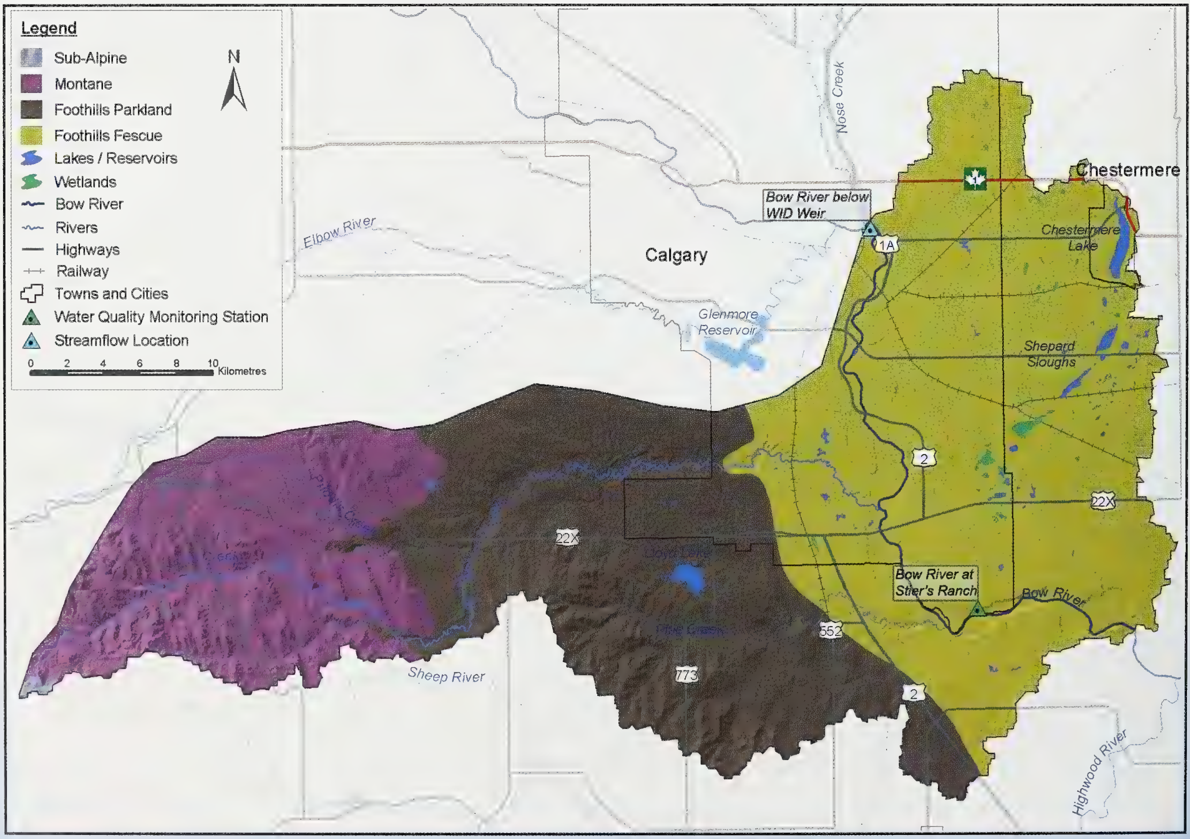


Table 7.3 Size and extent of Reach 5 features[23 39 40 45 195]

Natural Feature	Area (km²)	Extent of Reach (%)
Sub-alpine sub-region	1.4	0.12
Montane sub-region	226.3	19.91
Foothills parkland sub-region	364.6	32.06
Foothills fescue sub-region	524.9	46.17
Lakes	8.8	0.78
Reservoirs	0.8	0.07
Lagoons	1.6	0.14
Wetlands	4.1	0.36
Rivers	4.3	0.37
Canals	0.2	0.01
Total	**1,137**	**100.00**

the province, portions have never been tilled. As a result, some of the largest relatively intact parcels of foothills parkland in the province are found here, and are considered provincially significant.[228]

Native vegetation in the foothills fescue sub-region is characterized by grass species such as fescue and oatgrass. Native flowering plants and herbs include sticky geranium, prairie crocus, golden bean, prairie sagewort, American sweet vetch, low larkspur, heart-leaved buttercup, shooting star, and western wild parsley. Shrubby cinquefoil is a common shrub on rapidly drained sites along the foothills. Deciduous shrub and tree communities are found where water is locally more abundant, particularly along rivers and on north-facing slopes.[19]

Urban and rural residential developments limit wildlife habitat and reduce connectivity with other natural environments. Nevertheless, wildlife populations characteristic of the Rocky Mountain, parkland and grassland regions are found. Significant areas for wildlife within the City of Calgary include Fish Creek Provincial Park, Southland Natural Park and Inglewood Bird Sanctuary.

In particular, Fish Creek Provincial Park provides habitat for a wide variety of species. This park is the largest provincial park within an urban setting in Canada and its wildlife includes coyote, porcupine, weasel, beaver, snowshoe hare, muskrat, skunk, rabbit, Richardson's ground squirrel, red squirrel, pocket gopher, meadow vole, and mule and white-tailed deer. Periodically, black bear or cougar follow the Fish Creek Valley from the foothills into the park.[240]

The mixture of forests, shrubs and grasses within the landbase of this reach also attract a wide range of bird species including the bald eagle, red-tailed and Swainson's hawk, ruffed grouse, ring-necked pheasant, and great horned owl. Autumn bird counts in the Inglewood Bird Sanctuary indicate the presence of numerous species, including ruby-crowned kinglet, American redstart, eastern kingbird, least flycatcher, belted kingfisher, black-capped chickadee, cedar waxwing, and downy woodpecker.[240]

The Shepard Sloughs

The Shepard Sloughs (also called the Janet Sloughs) will be the first regional park to be developed in the City of Calgary's recently established Legacy Parks Program. The sloughs, located in southeast Calgary, were once a major prairie wetland complex but essentially disappeared following urban and agricultural development. In 2003, the City of Calgary and Alberta Environment entered into an agreement to construct the Shepard Stormwater Diversion Project. This project incorporates a canal and wetland system and is scheduled to begin operation in 2007. More than half the stormwater from Calgary, that used to be conveyed by the Western Headworks Canal to Chestermere Lake, will be diverted into the constructed wetlands of the sloughs. A set of control gates on the canal at the city limits will divert stormwater from the WID system to the wetland, improving the situation that has existed since 1963. Currently, stormwater from Calgary and Chestermere enters the Western Headworks Canal, negatively impacting the water quality and storage capacity of Chestermere Lake and the downstream canal operations of the WID.

This wetland will ultimately treat more than 50% of the stormwater from Calgary's east industrial parks, as well as water from northeast Calgary and Nose Creek. During the winter, when the WID system is shut down, snowmelt from Calgary will be diverted to the constructed wetland for treatment. At 240 ha, the restoration of the complex will incorporate a significant engineered wetland and will provide wildlife habitat. The opportunity to create a unique park with both educational and recreational opportunities is being pursued in conjunction with wetland design.

Riparian and Wetland Habitat

Much of the riparian area of Reach 5 has been negatively impacted from development within the City of Calgary. The Cows and Fish Program assessed the riparian health of this reach as healthy, but with problems. The floodplain functions more naturally than in Reach 4, and is generally well vegetated.[123] The greatest problem was the extensive distribution of invasive plants and weed species and the lack of native grasses.[38] Non-native species can crowd out native riparian vegetation and reduce the quality of habitat. Isolated patches of invasive purple loosestrife have been found growing along the streambanks of the river. Since the initiation of the Alberta Purple Loosestrife Eradication Program in 1994, the number of purple loosestrife plants within Calgary has dropped.

Tree and shrub cover along the riparian zone was considered healthy.[38] Riparian forests along the Bow River within Calgary typically exist on prominent point bars and close to the banks of the river. Beaver activity, however, has been a significant contributor to a decline in tree numbers along the river.[240] Balsam poplar is the dominant tree species, but other species include white spruce along the moist, shady, north-facing banks of the river. Spruce trees exist in mixed stands with balsam poplar and/or aspen, or in a mixed coniferous forest in association with Douglas fir. Large continuous aspen stands are found in Calgary and in the southern portion of this reach, mainly along escarpments, in ravines, and areas of minimal urban development or disturbance.[38 82] Browsing of trees and shrubs was found to be minimal within this reach.[38] This indicates the general absence of larger wildlife in the riparian areas along the Bow River mainstem, although there are resident populations of mule and white-tailed deer.[240]

In addition to urban development, commercial operations such as golf courses and gravel extraction also occur along the banks of the Bow River. The remaining riparian areas and riverbanks within Reach 5 are maintained by the city as naturalized park. The Urban Park Master Plan provides direction for park development and conservation throughout Calgary's river valleys.[240] While these areas are generally dominated by non-native grass and weed species, they remain important habitats for birds and small animals.[82] The Inglewood Bird Sanctuary, found at the upstream end of this reach, provides important songbird migration and overwintering habitat.[240]

Downstream of Calgary, to the Highwood River and the end of Reach 5, the riparian zone of the Bow River is healthier. The riparian forest is extensive and cottonwood and balsam poplar densities are moderate.[35] Ungrazed riparian woodland islands are also found along the shallow river valley in the lower section of this reach.[228]

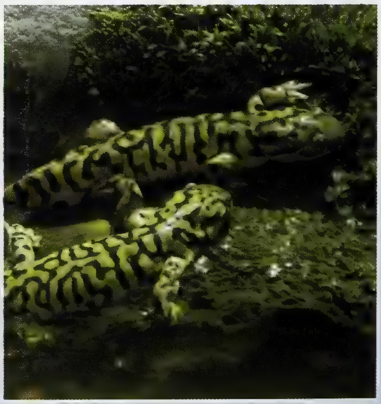
Like Reach 4, many wetlands within Reach 5 have been significantly altered or eliminated. Development within the City of Calgary has drained or filled in over 90% of the wetlands once found within its limits. (See Chapter 6 for a discussion on Calgary's wetlands and how the remaining wetlands are being protected.) Calgary's Bridlewood community is located near the southern boundary of the city and is an example of how well wetlands can function in urban areas.

Today, the majority of wetlands are found in the eastern portion of Reach 5 within the foothills fescue sub-region. Of note are the Shepard Sloughs. These sloughs provide habitat for waterfowl and are provincially significant for breeding eared grebe.[228] Chestermere Lake provides habitat for thousands of migrating geese, ducks and swans.[112]

Wetlands along the Bow River have been virtually eliminated due to streambank and urban development within the City of Calgary. Despite these changes,


Blue-winged Teal – A.MacKeigan


Purple Loosestrife


Salamanders – K.Richardson

waterfowl are common on the Bow River, with the banks used extensively by nesting Canada geese. Several large wetland complexes exist in other locations. Licensed water diverted to the WID is also used to create extensive wetland projects operated by Ducks Unlimited Canada. While the Priddis Slough has been steadily declining in size the last few years,[18] the Tsuu T'ina Nation includes a major wetland complex in the headwaters of Priddis Creek.[228] Policeman's Flats, located just south of Pine Creek, is a small backwater marsh area that provides important nesting habitat for waterfowl and songbirds.[240]

The Lafarge wetland complex is a large constructed wetland project planned along the banks of the Bow River. This wetland is an extension of Fish Creek Provincial Park and will transform a mined-out gravel pit, enhancing wildlife, fish and riparian habitat along the Bow River. Stormwater from adjacent development will be directed to the constructed wetland, eliminating the existing outfalls to the Bow River. This wetland will treat the stormwater and improve its quality prior to discharge to the Bow River.[168]

Reach 5 provides high priority nesting and brood production habitat for Canada geese, particularly on islands near the Inglewood Bird Sanctuary and Fish Creek Provincial Park. The large numbers of ducks and geese that overwinter in this reach highlights the effects of warm stormwater and wastewater effluents. Beaverdam Flats also provides overwintering habitat. Reach 5 is home to several active great blue heron rookeries as well as the American white pelican and double-crested cormorant. Other common birds include the mallard duck, common merganser, and ring-billed and California gulls. Occasionally present are harlequin duck, long-tailed duck, Barrow's goldeneye, and tundra and trumpeter swans.[240]

During spring migration, especially in years of drought or when lakes are still frozen, waterfowl and raptors use the Bow River. Species that can be seen along the Bow River during the breeding season include the wood duck, blue-winged teal, gadwall, common goldeneye, bald eagle, and osprey.

Aquatic Habitat

Reach 5 of the Bow River provides highly productive cold-water aquatic habitat. Modifications to the natural flow regime of the river, through higher winter flows and re-regulation by the Bearspaw Dam have had both positive and negative effects on aquatic habitat. The greatest benefit to aquatic habitat is the discharge of wastewaters from the City of Calgary's WWTPs. The Bonnybrook and Fish Creek WWTPs discharge nutrients that stimulate biological production and have contributed to the world-class sport fishery downstream of Calgary.[90]

As in upstream reaches, mountain whitefish is the most common species. The introduced rainbow and brown trout have been very successful within the Bow River and have largely replaced native species. Native cutthroat and bull trout once ranged from the headwaters to beyond Calgary, but are now rare in the mainstem within this reach.[163,165] The bull trout is listed as "sensitive" within Alberta (see Chapter 2), and all bull trout caught must be released.[44] The status of the cutthroat trout is listed as "secure" within Alberta.[44]

Other fish found in lower numbers within this reach include brook stickleback, northern pike, burbot, longnose dace, spoonhead sculpin, and longnose and white sucker.[35,236] Chestermere Lake has populations of yellow perch and northern pike.[112]

The River Valleys Committee (RVC)

The RVC champions the environmental, heritage, aesthetic, social, and economic values of Calgary's rivers and river valleys and creates opportunities for Calgarians to engage in related stewardship activities. In 2000, they produced 'Caring for Shorelands along Calgary's Waterways', a brochure that provides information on how to sustain and conserve Calgary's riparian areas. In 2001, the RVC partnered with the BRBC to take landowners along the Bow River for a raft tour. In the spring of 2002, the RVC, RiverWatch, and the BRBC hosted a workshop to discuss best management practices for property owners along the Bow River. In May 2002, RVC volunteers assisted with the organization and delivery of 'Breaking Ground: a Conference on Creating a Greener Healthier City.' The mission of the conference was to bring together community members and decision makers to exchange ideas and experiences, to strategize on green space design, and to discuss the political and financial challenges of urban green space development.

Enough habitat variability is found within the mainstem of the Bow River to support all salmonid life cycle requirements. Diverse substrate and channel types include potential spawning, nursery, rearing, and adult feeding habitats. Enhanced winter flows increase overwintering habitat along the mainstem of the entire reach. Important brown trout and mountain whitefish spawning areas are located throughout this reach. A side channel at Poplar Island, restored by Trout Unlimited, is now an important spawning site for brown trout.[236] An important mountain whitefish spawning site is located just downstream of the confluence with Fish Creek.[240]

The WID weir, located at the upstream end of Reach 5, has significant impacts on fish movement and migration. Although a fish ladder aids in upstream fish migration, the weir limits movement and reduces fish habitat connectivity between upstream and downstream reaches of the river.

The urban environment of Calgary also impacts aquatic resources through influences on water quality. (See Chapter 6 for a discussion of stormwater impacts on aquatic life.) The discharge of treated wastewater from Calgary's two WWTPs is the greatest point source impact on aquatic life of the Bow River. Moderate nutrient enrichment of a system may be seen by some as positive, and is cited as a contributor to Calgary's world-class fishery.[90 133]

Excessive aquatic productivity, however, can lead to negative impacts on aquatic life. Increased growth of algae and aquatic plants occurs downstream of the WWTP outfalls,[249] with nuisance algal growth observed as far back as the early 1940s.[133] Increased human population and wastewater discharge since then led to more prolific aquatic plant growth, changes to benthic invertebrate communities and to the fish kills that occurred occasionally in the Bow River during the 1960s and 1970s.[133]

Since the installation of enhanced nutrient removal at Calgary's WWTPs throughout the 1980s and 1990s, aquatic plant biomass at the *Bow River at Stier's Ranch* site has declined significantly, though it is still higher than upstream reaches. While reductions in phosphorus loading decreased the growth of aquatic plants, the greatest changes occurred following reductions in nitrogen loading.[216]

Streamflows also influence the growth of aquatic plants. In recent years, spring freshet flows have been lower than average and have permitted increased growth of rooted aquatic plants. Lower flows have reduced the scouring needed to flush away the sediments that accumulate and dead aquatic plant biomass during the year.[77]

7.5 Tributaries

Fish Creek

The largest tributary to this reach is Fish Creek, which joins the Bow River from the west, near the southern edge of the City of Calgary. Fish Creek originates in the foothills of the Rocky Mountains and flows through parkland and grasslands prior to entering the Bow River. The drainage basin is 439 km^2 in area. The creek meanders for 93 km through a wide valley that was formed by glacial meltwaters.

The riparian forest along the banks of Fish Creek is dominated by white spruce in the western headwaters. Farther east, the forest is dominated by balsam poplar, but also includes white spruce, aspen, and birch. Common shrubs include red-osier dogwood, buffaloberry, and bearberry.[21] The northern portion of the sub-basin includes lands in the Tsuu T'ina Nation. The lower half of the creek flows past Priddis and through the City of Calgary. A major feature of the sub-basin is Fish Creek Provincial Park, which is located at the lower end of the creek, entirely within the City of Calgary.

The foothills in the upper extent of the sub-basin are home to a wide variety of wildlife. Large mammals include elk, deer, moose, bear, coyote, and cougar. The river valley is essential for wildlife, particularly as urbanization increases within the lower portions of the sub-basin. Particularly important is Fish Creek Provincial Park, of which approximately 900 ha of its 1,348 ha remain in a natural state.[240] The varied landscape provides habitat for mule and white-tailed deer, coyote, beaver, porcupine, weasel, Richardson's ground squirrel, and the little brown bat.

Amphibians along the creek and in shallow ponds include the tiger salamander, wood frog, and boreal chorus frog.[21]While there are historical records of the northern leopard frog within Fish Creek Provincial Park, there have been no recent sightings.[258] Wandering and red sided garter snakes are found in the park; both species are categorized as "sensitive" within Alberta (see Chapter 2).[44]

During the 1990s, Trout Unlimited conducted an inventory to examine channel habitat and determine the status of fish populations in Fish Creek. Fish species in Fish Creek include rainbow, brook and brown trout, mountain whitefish, brook stickleback, and longnose and white sucker.[21] Native westslope cutthroat trout were relatively scarce and primarily confined to the uppermost reaches; native bull trout have all but disappeared from the creek. Fish Creek was an important spawning tributary for rainbow trout in the

Settlement history of Fish Creek

The Fish Creek Valley has a continuous record of human settlement for more than 8,000 years, and is being researched by archaeologists from the University of Calgary and Alberta Community Development. It is believed to be where humans first settled the Calgary area, and where Aboriginal communities grew and thrived for thousands of years. Humans are believed to have first settled in the area in small numbers around 6000 B.C., after glacial lakes covering the area had receded. The oldest identifiable artefact found is a broken spearhead, dated at around 2000 B.C. Other discoveries include several buffalo jumps and kill sites, projectile points, bones, and cooking utensils. Glass beads provide evidence of the local Aboriginal community's contact with European settlers during the late 19th and early 20th centuries. In 1873, the area's first grain crops were planted, followed closely by Alberta's first irrigation project. In 1883, a wool mill was established in the sub-basin – the first industry in Alberta.[239]

Fish Creek at mouth - M. Bennett

1970s; current spawning is minimal, apparently due to low flows. Because of varying and occasionally ephemeral water flows in the lower reach of the creek, very few fish are found in the area, with the exception of the area near its confluence with the Bow River.[226]

The headwaters of the creek flow through Kananaskis Country, which is a popular recreational destination. Recreational use of Fish Creek Provincial Park, farther downstream, is heavy year-round and includes an extensive network of bicycle and pedestrian paths, opportunities for cross-country skiing, skating, swimming, boating, equestrian and hiking.[240] Commercial land uses within the sub-basin include ranching and gasfield development. Once the creek enters Calgary, the landbase also drains residential and commercial areas, and the creek receives stormwater and urban runoff from the City of Calgary. Direct stormwater discharges from Calgary, however, have been greatly reduced. Treatment wetlands and settling ponds now receive and treat the stormwater through natural processes. This treated stormwater enters Fish Creek through wetland infiltration and groundwater seepage.[21]

7.6 Where are we Headed?

Reach 5 of the Bow River is included in Phase 2 of the South Saskatchewan River Basin's Water Management Plan (see Chapter 2). Instream flow needs have been determined for several ecological criteria in Reach 5, including water quality, fish habitat, riparian vegetation, and channel structure.[90] After the Water Management Plan is approved, the Government of Alberta will set a Water Conservation Objective (WCO). The WCO will attempt to establish a balance between water consumption and environmental protection of the river, and will determine the maximum amount of water that can be allocated.[24]

Though it is expected that agricultural use will decline, urban development is certain to increase. The senior priority of irrigation licensees, including the WID, means there are limited opportunities for future allocations in this reach of the river. Wastewater production volumes can generally be linked to water consumption, and as Calgary continues to grow, waste loadings to its WWTPs will also continue to grow.

Modifications to the WID Weir

Originally built in 1904 and rebuilt in 1975, the WID weir has long presented a problem to fish and recreational users of the Bow River. While the weir contains a fish ladder to aid movement of fish from downstream, fish migration is still limited. The hydraulic roller design of the weir makes it impassable to boaters and very dangerous to recreational users, prohibiting this activity in its vicinity. Proposals to modify the weir have been discussed since the mid 1980s. A recent proposal by the Calgary Parks Foundation envisions diverting water into the irrigation canal and creating two safe, mid-stream channels past the weir. The existing headworks structures and the WID system would not be altered. This design would increase fish passage, allow safe navigation by boats, and have a component for more advanced kayaking and canoeing. However, the removal of the hydraulic roller would negatively impact the ability of the American white pelican to continue to fish below the existing weir.[187]

WID weir modifications – artist's renditions – K.Richardson

Conservation efforts have allowed total municipal water use to remain approximately the same for the last 25 years, and the City of Calgary has a strategic plan in place to maintain this trend. Regardless, the effluents released by Calgary's WWTPs will be increased when the Pine Creek WWTP becomes operational in 2007. The future impacts and loadings from Calgary's WWTPs to the Bow River will depend on how the facilities respond to higher influent concentrations. Calgary will also soon operate under a new provincial approval for wastewater discharge, and the WWTPs will be required to comply with limits for nutrient loading.[77]

A positive trend is the expanded regional wastewater servicing agreements with high growth communities surrounding Calgary (Cochrane, Chestermere, Airdrie, and the Tsuu T'ina Reserve). By coordinating wastewater treatment and monitoring of effluent discharges, these communities are able to take advantage of Calgary's state-of-the-art WWTP facilities and reduce their impacts on the water quality of the Bow River.

Due to the already high and increasing pressures on water resources within Reach 5, it is important to collect comprehensive information on which to base predictions and make management decisions. There is no streamflow monitoring station in Reach 5, but the approximate flows at this location can be been calculated just below the WID weir. Impacts from wastewater effluents on water quality are being studied, with limits on total nutrient loadings soon to be established.

The WWTPs and industries also monitor the quality of effluent they discharge to the Bow River. These monitoring programs provide an excellent basis for the status of water quantity and quality in this reach. However, no long-term water quality monitoring station is located within this reach, despite the fact that the City of Calgary's WWTPs are the two single largest sources of pollutants and have the greatest human impact on the water quality of the Bow River Basin. The establishment of a new water quality and aquatic ecosystem monitoring station downstream of the mixing zone of the planned Pine Creek WWTP would greatly improve the understanding and management of the Bow River within Reach 5.

Chapter 8

Sheep River – A.MacKeigan

Chapter 8

Reach 6 – Highwood River confluence to Upstream of Carseland Weir

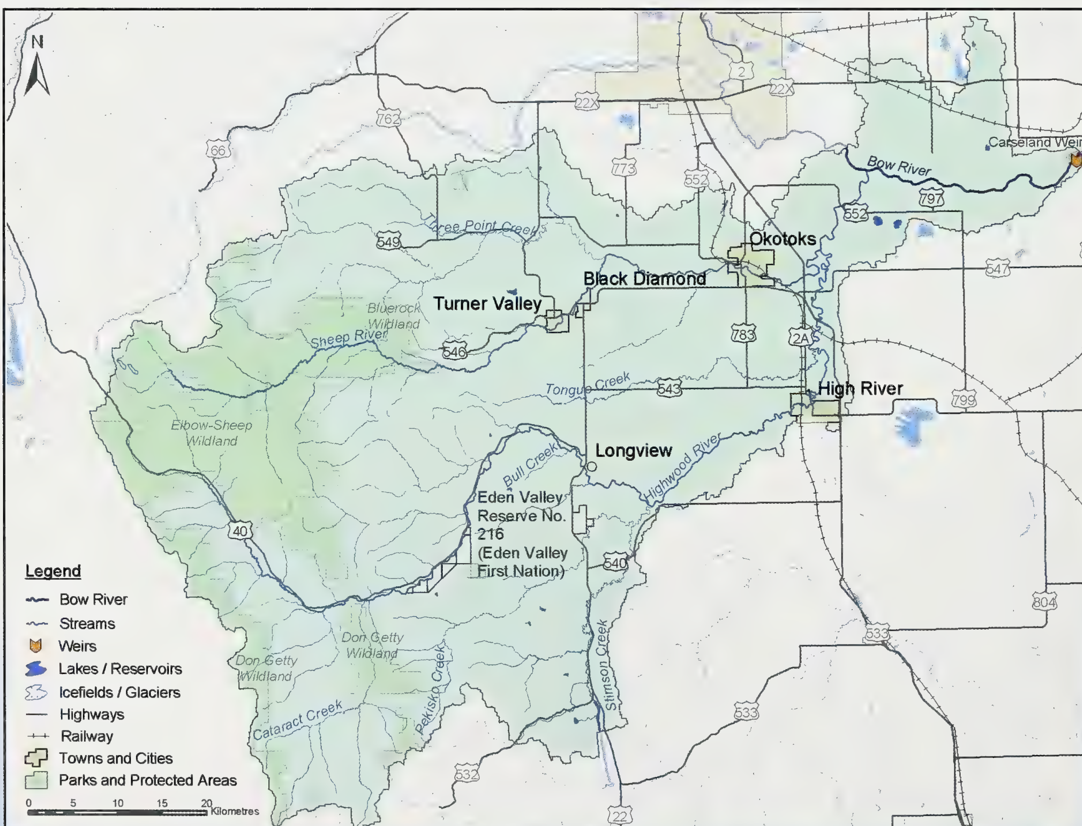
8.1 What is in this Reach?

Within Reach 6, the Bow River winds its way through the prairie, east from the Highwood River confluence, through the Municipal District of Foothills No. 31, to the Bow River Irrigation District (BRID) weir at Carseland (Figure 8.1). Due to a lower gradient, the river flows more slowly through the prairie than in the mountains and foothills farther upstream. The total length of Reach 6 is 34 kilometres (km); it drains an area of 4,387 square kilometres (km^2). The Highwood River, the main tributary, enters the Bow River from the southwest near the upstream boundary of Reach 6. The Sheep River is the most significant of the Highwood's several tributaries.

The landscape is diverse. The alpine and sup-alpine areas of Kananaskis Country border the western edge. Farther east, the landscape changes to forested foothills, then to grassland. A diverse array of wildlife, including golden eagle, bighorn sheep, cougar, elk, moose, and bear, is found in the mountains and foothills. The grassland portion provides habitat for coyotes, mule deer, white-tailed deer, Richardson's ground squirrels, red-tailed hawks, and other grassland bird species.[57]

In the grassland portion, the Bow River flows through a wide floodplain that supports riparian poplar forests and is home to mule and white-tailed deer. Wetland habitat within the floodplain is limited due to

Figure 8.1 Overview map of Reach 6[16 39 45]



the steep banks of the river. However, these steep cliffs provide important nesting habitat for geese and some locally important wetland habitat is found in the side-channels upstream of the Carseland Weir.[57]

Reach 6 is cold-water fish habitat and like Reach 5, supports a world-class recreational trout fishery in the Bow, Highwood and Sheep rivers. The most common sportfish species are mountain whitefish and the introduced brown and rainbow trout.[71]

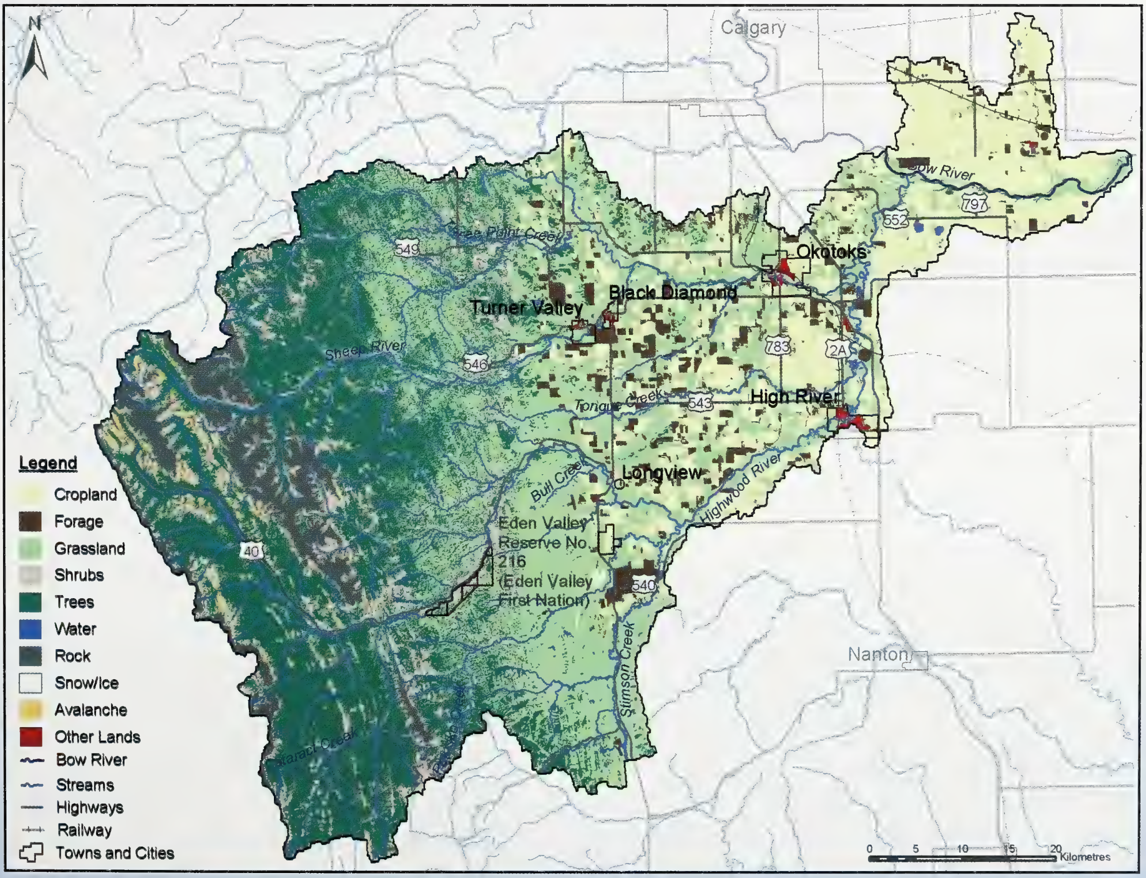
The Elbow-Sheep Wildland Park, Sheep River Provincial Park, Bluerock Wildland Park, and Don Getty Wildland Park are located in the mountains and foothills of the upper reaches of the Highwood and Sheep rivers. Wyndham Carseland Provincial Park is located near the Carseland Weir in the grassland area. Approximately 16.9% of the land has some form of park status.

There are no communities directly adjacent to the banks of the Bow River. However, several communities are found within the Highwood River sub-basin, including Black Diamond, Turner Valley, Okotoks, Longview, High River and Eden Valley Reserve No. 216, home of the Eden Valley First Nation. These communities rely on groundwater from shallow wells for their water supply. Their sewage effluent is discharged to the Sheep or Highwood rivers, and eventually makes its way to the Bow River. Water quality and quantity in Reach 6 are therefore influenced by activities in these communities.

In 2003, the population was about 36,500 people.[36] Okotoks has doubled in size in the last decade, from 6,720 in 1991 to 11,664 in 2003. High River is about 50% larger, increasing from 6,269 in 1991 to 9,345 in 2003. Similarly, the Municipal District of Foothills has grown from 10,912 in 1992 to 17,682 in 2003.

Ranching has been the predominant land use for more than 100 years. Grain and forage crops are grown, mainly to support ranching operations. There are also chicken, pig and sheep farms and a few feedlots. Oil and gas is the main industrial land use.

Figure 8.2 Land use of Reach 6[6 39 45]



Trout fishing is also a major activity on the Bow River in this reach. The Highwood and Sheep river valleys are popular recreational destinations. Activities include hiking, camping, mountain biking, cross-country skiing, horseback riding, golf, and fishing.

8.2 Hydrology

The natural flows of the Bow River in Reach 6 are illustrated in Figure 8.3, which shows the average weekly discharge of the Bow River above the Carseland Weir (Figure 8.5, page 133). There is no flow gauging station in Reach 6, but the approximate flows at this location have been calculated as the sum of flows from the *Bow River below Carseland Weir* (Water Survey of Canada station AB05BM002) and the *Bow River Development Main Canal* (Station AB05AC004) (see Chapter 1). Natural streamflows peak in early June, averaging around 375 cubic metres per second (m^3/s). Natural baseflows, which consist mainly of groundwater, occur from November to March and average around 30 m^3/s.

The average recorded flows (Figure 8.3) show the modified flow regime for the Bow River above Carseland Weir as a result of upstream hydroelectric dams and water withdrawals. The average recorded spring discharge peaks have decreased to around 285 m^3/s, while baseflows have increased to an average of 60 m^3/s. The flows contributed by the Highwood River somewhat moderate the influence of upstream dams.[123]

How do Water Withdrawals Affect Hydrology?

Table 8.1 shows the water licence allocations for the Bow River in Reach 6 for 2002, as provided by Alberta Environment. The total volume of water licensed for diversion by all users was about 14 million cubic metres (m^3) in 2002. These extractions represent less than 0.5% of the long-term average flow for the Bow River above Carseland Weir. The water extractions within Reach 6 are cumulative with those from upstream reaches and have resulted in substantial changes to the natural flow regime of the Bow River (Figure 8.3).

In 2002, the annual licensed allocation (consumptive uses plus water losses and return flows) for irrigation and agriculture was about 14 million m^3, more than 99% of the total licensed allocation for Reach 6. Actual

Table 8.1 Licensed allocation of the Bow River in Reach 6[108 193]

Water User	Annual Licensed Allocation (m^3)	Percentage of Annual Average Bow River Discharge (%)[a]
Industrial	0	0
Irrigation & Agriculture	14,119,917	0.35
Municipal	3,700	< 0.01
Other	50,560	< 0.01
Total	**14,174,177**	**0.36**

[a] Average annual natural discharge of Bow River above the Carseland Dam is 3,949,611,434 m^3 (1912-2001)

Figure 8.3 Discharge of the Bow River above Carseland Weir (1971 – 2001)[29]

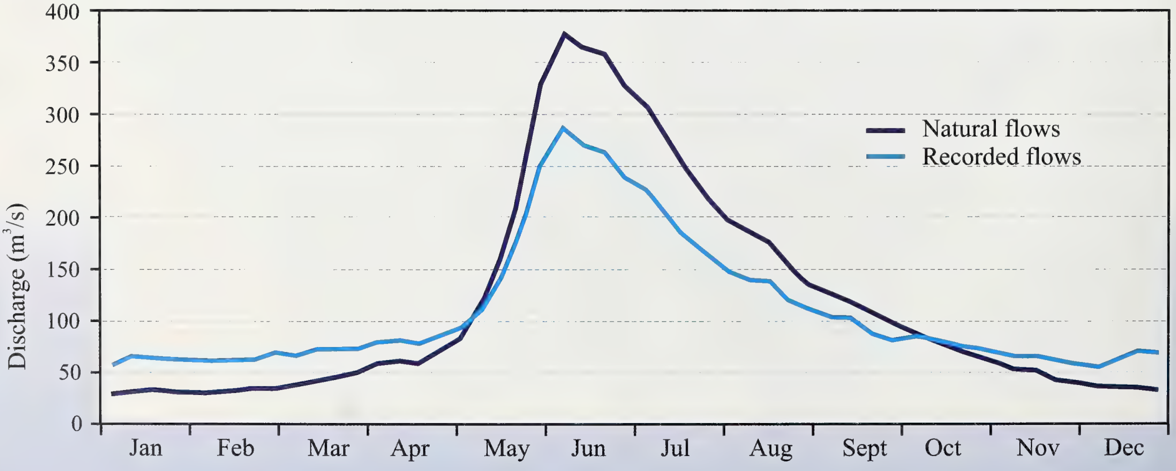


Table 8.2 Licensed and estimated annual consumption and returns to the Bow River in Reach 6[193]

Water User	Annual Consumption from the Bow River (m³)		Annual Return Flows to the Bow River (m³)	
	2002 Licensed	2002 Estimated[a]	2002 Licensed	2002 Estimated[a]
Industrial	0	0	0	0
Irrigation & Agriculture	14,119,917	7,600,324	0	0
Municipal	3,700	3,700	0	0
Other	50,560	0	0	0
Total	**14,174,177**	**7,604,024**	**0**	**0**

[a] When water use reports for each license are absent, the licensed consumption and licensed return flows are used to approximate the estimated consumption and return flows, respectively. This likely overestimates the estimated consumption and return flow data in this reach

consumption of water for irrigation and agriculture varies greatly from year to year (Table 8.2). In 2002, estimated irrigation and agricultural consumption was 7.6 million m^3 or about 54% of the licensed consumption.

In 2002, less than 1% of licensed water extractions in Reach 6 were for uses other than irrigation/agriculture. The communities do not withdraw water directly from the Bow River and their water extractions and return flows are not included in this discussion.

Although Table 8.2 lists no return flows for any water users in Reach 6, this does not accurately reflect water use and returns by these licensees. Because no return flows are specified within their licences, the licensees did not file water use reports in 2002. Despite the lack of information, it is likely that some return flows are provided by most of the licensees.

How does Land Use Affect Hydrology?

Approximately 968 km^2 (22.06%) of the landbase in the Reach 6 watershed has been cleared (Figure 8.2). The major human land use is ranching, with some agricultural crop production. A large percentage of the land is in pasture and most of the crops grown are used for livestock feed or as part of planned crop rotations to support forage production. In the area east of Black Diamond, farming is more diversified, though still dependent on raising beef cattle, dairy cows, swine, poultry, and sheep.

The intensity of grazing and agriculture is lower than in downstream reaches, but there is no site-specific data on the impacts of these land-use practices on the water quantity of the Bow River or its sub-basins within Reach 6 (see Chapter 2).[41]

A small amount of forestry activity occurs at the western edge of the Highwood River sub-basin. Spray Lake Sawmills has a Forest Management Agreement (FMA) that includes 97,729 ha within the landbase of Reach 6 (see Chapter 2).

Farming along the Sheep River – J. Toews

Spray Lake Sawmills Aquatic Monitoring Program

As part of their commitment to the environment, Spray Lake Sawmills (SLS) continually works to improve their harvesting and reforestation programs through monitoring and research. SLS's Aquatic Ecosystem Monitoring Program has been monitoring streams in the Bow River Basin since 1996, including six tributaries of the Elbow River and six tributaries of the Highwood River. The objectives are to collect data to assist in the development of regionally-specific ecosystem-based timber harvest plans, and to develop a framework that allows the identification and evaluation of changes in aquatic resources over time. The program monitors:

- biological diversity of benthic invertebrates
- presence or absence of sportfish
- stream habitat measurements and classification
- temporal patterns in water quality

Timber harvesting

Watershed protection and the maintenance of water quality are primary objectives during the timber harvest planning and operating stages. Harvest planning and operating standards and guidelines are based on the watercourse classification. They set the requirements for stream crossing structures, road location and buffer widths. Locations and structures for stream crossings are selected to protect streambanks and channels, while minimizing the risk of sediment entering the watercourse. SLS monitors roads and stream crossings on an ongoing basis until they have been reclaimed and stabilized.

SLS has successfully completed three independent audits of their mill and woodlands under the voluntary certification ForestCare Program. They also received an Emerald Award in 2000 for demonstrating their commitment to the environment.

8.3 Water Quality

The most significant point source influences on the water quality in Reach 6 are the City of Calgary's Bonnybrook and Fish Creek wastewater treatment plants (WWTPs), located upstream.[249] Over the past 20 years, the City of Calgary has performed numerous upgrades to its wastewater treatment capacity and has greatly reduced suspended solids, organic material, bacteria, and nutrient loading to the Bow River.[117 249]

Reach 6 is also influenced by the water quality of the Highwood River, which drains a large landbase that includes the foothills and several communities. Most of the communities discharge stormwater and treated wastewater effluent into either the Sheep or the Highwood rivers, and this eventually makes its way to the Bow River.

A sewage lagoon in Black Diamond treats wastewater from Black Diamond and Turner Valley to a primary level. Effluent from the lagoon is discharged to the Sheep River. Okotoks, which discharges wastewater to the Sheep River, has currently developed a water management plan and is in the process of upgrading its wastewater treatment facility. (See sidebar on Town of Okotoks Water Management Plan, page 139).[235]

The Village of Longview and Eden Valley No. 216 use sewage lagoons for wastewater treatment. The effluent is discharged to the Highwood River and ultimately reaches the Bow River. Although the Town of High River is also located on the Highwood River, it discharges its treated sewage to the diversion that transfers water from the Highwood River to the Little Bow River in the Oldman River Basin.[203]

Other influences on the water quality of the Bow River in this reach include surface water runoff from industry, agriculture, grazing, and forestry practices. Little specific information exists regarding their impact on water quality on Reach 6 of the Bow River.

Water Quality of the Bow River Below Carseland Weir

Water quality in the Bow River is measured by Alberta Environment downstream of the Carseland Weir as part of their long-term river network (LTRN) monitoring program. This site is actually at the top end of Reach 7, but since it reflects the influences on water quality from activities in Reach 6, it is discussed here. The site is named *Bow River below Carseland Weir* (AENV LTRN Site 00AL05BM0002) (Figure 8.5). Recent water quality assessments of data collected at this site include the determination of Water Quality Indices (WQI) for several suites of key variables, including metals, nutrients, bacteria, and pesticides. An overall average WQI has also been generated for this site based on the results of these suites of variables.[27]

The WQI has been calculated at this site for the past decade, spanning 1990 to 2001 (Figure 8.4). The averaged WQI for the site rated the water quality as fair in 1996 and good from 1997 to 2001. The improvement in the overall water quality rating over time was a result of substantially better ratings in the bacterial variables, which are linked to improved wastewater treatment.

Nutrients rated fair throughout the period of record, with both nitrogen and phosphorus exceeding water quality guidelines for the protection of aquatic life. These exceedences suggest that nutrient enrichment has increased the productivity of the system and altered the aquatic community (see Section 8.4). Synoptic surveys of the Bow River indicate that in this reach, the Bonnybrook and Fish Creek WWTPs are the largest point sources of nutrients and the Highwood River is the largest tributary source of nutrients.[249]

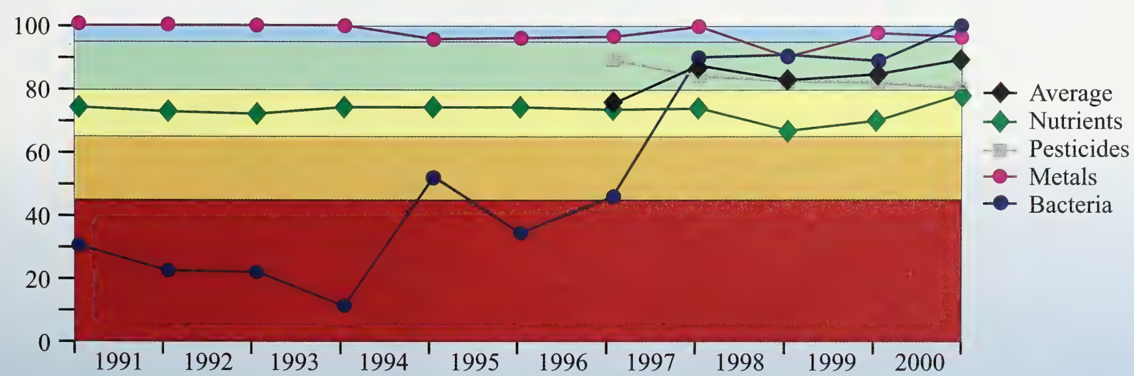
Nutrient levels in Reach 6 remain elevated and are higher than in reaches upstream of Calgary, despite the great improvements to wastewater treatment and nutrient removal over the last few decades. These improvements in wastewater treatment, however, will probably be offset by future population growth, with an overall result of increased nutrient loading to the river.

Pesticides were not rated until 1995/1996. Pesticide ratings for most of the sampling period at this site were rated as good but declined to fair in 2000/2001when a few concentrations of diazinon, MCPA, MCPP, and 2,4-D were detected. MCPA, an herbicide used to control broadleaved weeds in cereals and grassland, was found to occasionally exceed water quality guidelines for irrigation and the protection of aquatic life. While fewer samples had detectable levels of pesticides in 2000/2001 compared to previous years, the concentrations of the detectable pesticides increased, resulting in the slight WQI decline to a fair rating.

One year's worth of data is not enough to suggest an increasing trend of pesticide concentrations at this site, however, it does point to the need to closely monitor water quality and improve pesticide management. The results may be influenced by the focus on spring and summer sampling in the later years, compared to year round sampling in the earliest year. Improved pesticide ratings may occur in the future if Calgary and other communities continue to discourage residential pesticide use and end their cosmetic use on lawns and parks. Pesticide levels are also related to surface runoff from agriculture, which covers approximately 20.8% of the landbase in this reach.

Bacterial concentrations within Reach 6 have shown the most dramatic improvements over time. Bacteria rated poor to marginal from 1990/1991 to 1996/1997, then increased to a good rating from 1997/1998 to 1999/2000. In 2000/2001, this rating improved further to excellent. Throughout most of the 1990s, risks for

Figure 8.4 Canadian water quality index for the Bow River below Carseland Weir[27]



recreational users were substantial, with high fecal coliform and *E. coli* counts that had the potential to cause eye and skin irritation. Bacteria counts during this time also exceeded the guidelines for irrigation use. In 2000/2001, however, bacterial concentrations were consistently below guidelines.

Synoptic surveys of the Bow River in the mid-nineties indicate that fecal coliform loading in the Bow River was primarily due to point sources (about 80% in summer and 96% in winter).[249] Major point sources of fecal coliforms include the Bonnybrook and Fish Creek WWTPs; the Highwood River contributed a small portion of the fecal coliform loading in Reach 6. Fecal coliform loadings from non-point sources such as agricultural runoff are not easily quantified, but likely contribute to the bacterial concentrations in the river.[203] The improved bacterial ratings in the late-nineties are likely due to improvements in disinfection and wastewater treatment by municipalities discharging into the Bow River. In particular, Calgary's wastewater effluent is now treated with ultraviolet light to sterilize bacteria.

Ratings of metals were consistently excellent over the sampling period, with the exception of 1998/1999, when metals were rated as good. During this time, cyanide and copper samples exceeded the water quality guidelines for the protection of aquatic life on one occasion each. In all other years, a maximum of one sample annually exceeded water quality guidelines. These slightly elevated metals concentrations occurred occasionally, were transient and were of no concern for long-term water quality or aquatic organisms. The sources of these metals include wastewater effluent from Calgary and natural tributary sources.[249]

8.4 Ecosystems

Terrestrial Habitat

The landbase of Reach 6 intersects the Rocky Mountain, parkland and grasslands natural regions and therefore, contains a diverse range of ecosystems and habitats. Natural sub-regions include the alpine, sub-alpine, montane, foothills parkland, and foothills fescue (Table 8.3).[19]

The upper elevations and western portion are located within the alpine, sub-alpine and montane sub-regions.[19] Vegetation and wildlife characteristic of the alpine and sub-alpine sub-regions are described in Chapter 3. Within the montane, white spruce, balsam poplar and trembling aspen forests are commonly found on wetter sites. Lodgepole pine, Douglas-fir and limber pine are found on drier land.

The foothills parkland sub-region forms the transition between the montane in the west and the foothills fescue in the eastern portion of the Highwood River sub-basin. Vegetation is a mixture of forest and grassland species. Aspen dominates the forest in upland areas and balsam poplar in moister areas.[19] A variety of shrubs and herbs such as saskatoon, snowberry, white meadowsweet, and cream-coloured peavine are found. Grassland species are typical of the foothills fescue sub-region.

Native vegetation in the foothills fescue is characterized by grass species such as fescue and oatgrass.[19] Native flowering plants and herbs are diverse. Shrubby cinquefoil is common in well-drained areas where grazing pressure is high. Deciduous shrub and tree communities develop where water is locally more abundant, particularly along the rivers, around the margins of lakes and on north-facing slopes.

Due to the diversity of vegetation communities, wildlife habitat varies greatly. See Chapters 3 and 4 for details on the wildlife habitat commonly found in the alpine, sub-alpine and montane sub-regions. Abundant populations of mule deer and white-tailed deer, as well as elk and moose are found within the landbase of Reach 6. Both mule deer and white-tailed deer use the river valley floodplains throughout the year for shelter, food and water. Foraging on hay and grain crops in the

Table 8.3 Size and extent of Reach 6 features[23 39 40 45 195]

Natural Feature	Area (km^2)	Percentage of Reach Area (%)
Icefields	0.8	0.02
Alpine sub-region	256.7	5.85
Sub-alpine sub-region	1,081.6	24.66
Montane sub-region	1,039.2	23.70
Foothills parkland sub-region	1,037.8	23.66
Foothills fescue sub-region	945.5	21.56
Lakes	6.9	0.16
Reservoirs	1.7	0.04
Lagoons	0.3	0.01
Wetlands	3.2	0.07
Rivers	11.8	0.27
Canals	0.1	< 0.01
Total	**4,385.6**	**100.00**

surrounding uplands augments their diet.[57] Native grasslands in the area support many mammals and birds, some of which are at risk, at least in part, because of the human impacts on grassland habitat.[44]

Several areas are considered environmentally significant for their diverse and abundant plant and animal life. Nationally, provincially and regionally significant areas in the higher elevations include the Highwood Pass, Mist Mountains Grasslands, and Wildlife Management Units AB406 and AB404.[237] In the foothills and grassland areas, environmentally significant areas include the Sheep River, Highwood-Pekisko Upland, Pekisko Creek, and the Okotoks Erratic (Big Rock).[228]

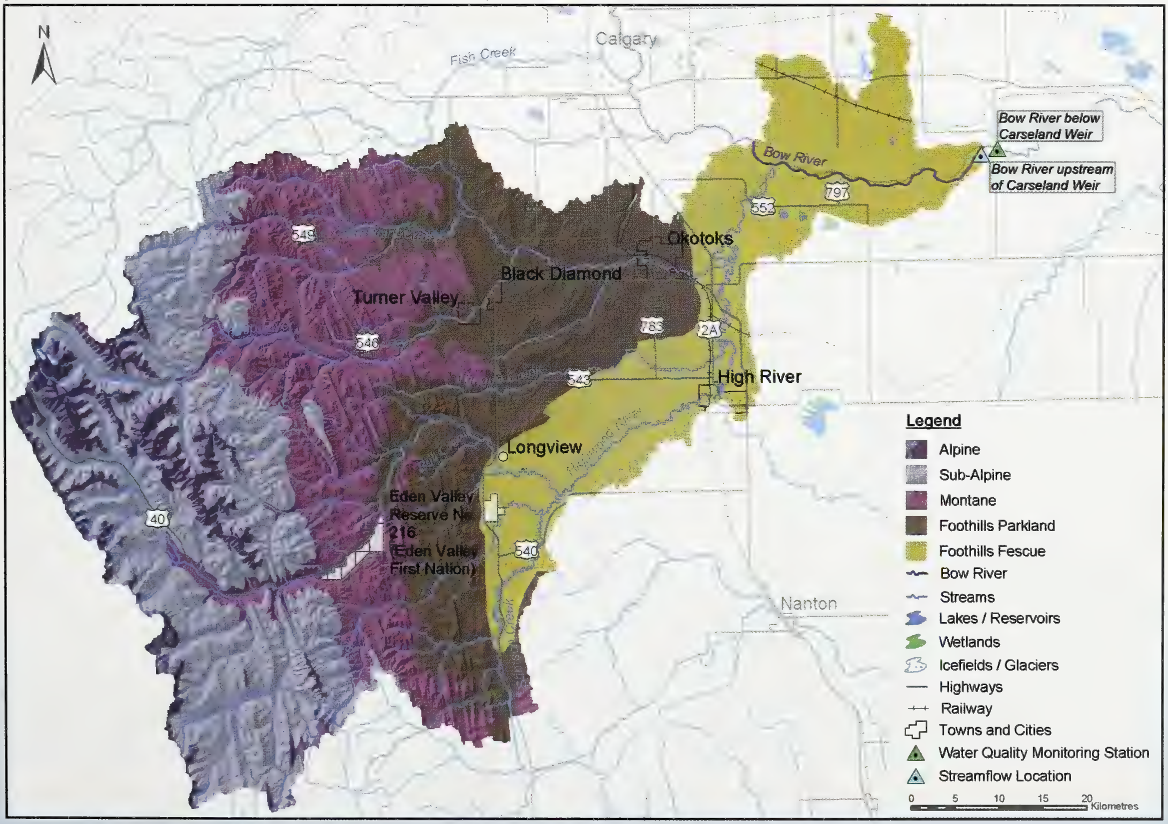
Riparian and Wetland Habitat

In Reach 6, the Bow River meanders through a broad floodplain, between 300 and 1,500 m wide. The floodplain supports riparian poplar forests; conifers are found along the north-facing slopes, and shrubs and grasses along the more arid south-facing slopes. The riverbanks are relatively steep, with vertical cliffs in some areas. The floodplain has not been structurally altered, and is only influenced by changes to the natural flow regime.[123]

Riparian forest spans the entire length of Reach 6 from the confluence of the Highwood River to upstream of the Carseland Weir. Dominant species are balsam poplar and narrow-leaved cottonwood.[90] The density of these riparian forests has decreased slightly since the late 1800 s. Mature trees provide nests for red-tailed and Swainson's hawks and exposed vertical cliff faces offer nest sites for the rock dove, prairie falcon and swallows.[57] Beaver inhabit marshy backwaters of former stream channels.

Riparian health was assessed by the Cows and Fish Program,[38] which found this reach to be healthy, but with problems. A high proportion of disturbance-caused plants and invasive plant species were found. Common invasive plant species include Canada thistle, common tansy, scentless camomile, perennial sow thistle, and leafy spurge. Native grasses are still present, but have the potential to be crowded out by invasive plant species. Because riparian forests are dependent on

Figure 8.5 Natural sub-regions and measuring locations of Reach 6[23 39 40 45 195]



flooding for the recruitment of new saplings, their health is also influenced by damming and water withdrawals. The flows contributed by the Highwood River in Reach 6 moderate the negative influence of upstream dams.[201] Consequently, cottonwood regeneration is considerably better within this reach, compared to other reaches of the Bow River.

While the steep banks of the Bow River valley limit wetland habitat, important good and duck habitat is still present. A locally significant wetland, located in the side-channels just above the Carseland Weir, provides important habitat for brood rearing for waterfowl. A great blue heron rookery is located approximately 5 km upstream of the weir.[57]

Aquatic Habitat

As in upstream reaches, Reach 6 is cold-water aquatic habitat. Mountain whitefish are the most common sportfish species found in Reach 6, followed by rainbow and brown trout.[71] The success of these two introduced species in the Bow River has led to substantial declines in native species, particularly bull and cutthroat trout. Bull trout are still present in very low numbers in the Bow River downstream of the Highwood River and near the confluence with the Highwood River.[226] Bull trout spawn in the upper reaches of the Highwood and Sheep River during fall. Most of them migrate out of the Bow River into the Highwood River before summer, to avoid high water temperatures in the lower reaches of the Highwood River during this time.

Though they prefer the warmer flows of Reaches 7 and 8, low numbers of yellow perch, northern pike, and burbot are also found in Reach 6.[193] Non-sportfish species include white sucker, longnose sucker, longnose dace, brook stickleback, and fathead minnow, spoonhead sculpin, and trout-perch.[90]

The portion of the Bow River from the City of Calgary to Reserve 146 (home of the Siksika Nation), which includes Reaches 5, 6 and the upper part of 7, is an internationally known recreational trout fishery.[216] Like upstream reaches, the flows in Reach 6 are influenced by hydroelectric dams, which result in higher winter baseflows than would occur naturally.

Decades of nutrient loading have resulted in eutrophication (increased productivity) of the aquatic system. Since nutrient removal was implemented at the Calgary WWTPs during the last few decades, algal growth within Reach 6 has decreased toward more natural levels.

The presence of dams and water control structures influences the movement of fish within the Bow River system. In the past, the Carseland Weir was a physical barrier to fish movements between Reaches 6 and 7. In 2003 and 2004, Alberta Transportation refurbished the Carseland Weir and the associated fishway. Subsequent monitoring indicates that mountain whitefish and rainbow and brown trout successfully use the fishway.[197]

The upper reaches of the Highwood and Sheep rivers are important mountain whitefish and bull trout spawning areas,[226] with some mountain whitefish spawning in the mainstem of the Bow River within this reach.[71]Rainbow trout spawning areas have not been reported in Reach 6. These fish are known to migrate long distances for spawning, and spawning areas have been documented in upstream reaches, below the Carseland Weir in Reach 7, and in the Highwood River.[22 197] Brown trout spawn in the mainstem Bow River, its side-channels and in the Elbow River.[71 193]

Beaver pond near Black Diamond – J.Thews

8.5 Tributaries

Highwood River

The largest tributary of the Bow River in Reach 6 is the Highwood River. The Highwood River originates in the Highwood Range of the Rocky Mountains. From the mountains, it flows through the foothills and enters the prairies, joining the Bow River about 8.2 km southeast of Calgary. The Highwood River is 162 km in length and drains an area of 2,412 km^2. The largest tributary of the Highwood River is the Sheep River; smaller tributaries include Tongue, Bull, Pekisko, Sheppard, Stimson, and Cataract creeks.

Because it has no major impoundments, flows of the Highwood River are relatively unchanged from natural, with the exception of relatively small agricultural withdrawals throughout the watershed.[123]

Don Getty Wildland Park is located in the upper reaches of the Highwood River. There are also several environmentally significant areas in the upper elevations of the Highwood sub-basin.[237] Highwood Pass has unique geological features including nunataks, synclines, cirque tiles, and a rock glacier. It also has rare alpine vegetation communities. At 2,230 m, it is the highest drivable mountain pass in Canada. South of the Highwood Pass are the high elevation Mist Mountain Grasslands.

The Highwood River Valley provides important habitat and movement corridors for grizzly bear, cougar, wolves, elk, deer, and moose, particularly in Wildlife Management Units 404 and 406, which extend north along the eastern slopes of the mountains. Pekisko Creek and the Highwood-Pekisko Upland are provincially significant areas that provide important elk and moose habitat.[237]

The Highwood River also provides important habitat for the harlequin duck, which breeds regularly along its major tributaries.[213] These ducks require fast-flowing streams, with healthy benthic invertebrate populations, urrounded by undisturbed shrubs and mature forests. In Alberta, harlequins are listed as “sensitive” (see Chapter 2).[44]

The Highwood River and its tributaries are instrumental in supporting the cold-water recreational fishery of the Bow River. Mountain whitefish presently dominate the fish fauna of the Highwood River system. They spawn throughout the mainstem and move downstream to overwinter in the lower reaches of the Highwood and Sheep rivers and in the Bow River. Rainbow trout is the second most abundant fish species in the Highwood drainage. This sub-basin provides more than 75% of the spawning and nursery habitat for the lower Bow River's rainbow trout population.[197]

In general, spawning and rearing rainbow trout tend to be concentrated in headwater tributaries and the upper reaches of the mainstem of the Highwood River. Brook trout are the dominant species in the headwater streams of the Highwood drainage.

While mountain whitefish are native to the Highwood River, the rainbow and brook trout have been introduced. Their success has been at the expense of native species like the bull and cutthroat trout. Bull trout are now rare in the Highwood River. Where their distributions overlap, brook trout tend to displace bull trout by competition for spawning locations, resources, space, and through interbreeding. The increase in rainbow trout populations may have contributed to the decline of native cutthroat trout in the Highwood River.

Cutthroat trout have been eliminated from the Highwood River below the Forest Reserve boundary and from all but short, isolated reaches of a few tributaries.[163] Evidence suggests there are now very few pure cutthroat trout in the Highwood River system,[226] rather, hybirds of cutthroat and rainbow trout exist.

Land use within the Highwood River sub-basin includes forestry, recreation, ranching and livestock operations, agricultural crop production, and oil and gas operations. Forestry occurs in the upper reaches of the Highwood River. Spray Lake Sawmills has a Forestry Management Agreement that includes 58,459 ha within the Highwood River sub-basin (and 35,330 ha in the Sheep River sub-basin). Recreation is common throughout the sub-basin and includes hiking, camping, mountain biking, cross-county skiing, horseback riding, golfing, hunting, and fishing.

A summer water quality monitoring program on the Highwood River has been in existence since 1989 but measures only temperature, dissolved oxygen, conductivity, and pH. It does not include sediment, nutrients or bacteria loading, although the Highwood River receives some very small wastewater discharges from Longview, as well as runoff from ranching and agricultural production that contributes nutrients and pathogens to the river.

However, in a study conducted in a similar area south of Reach 6, researchers found that in heavily grazed pastures, the presence of parasites was detected in very few runoff water samples and posed little risk of

contamination to adjacent streams. Nutrient contamination of adjacent water bodies was also found to be of little concern, though sediment runoff was a potential issue.[160]

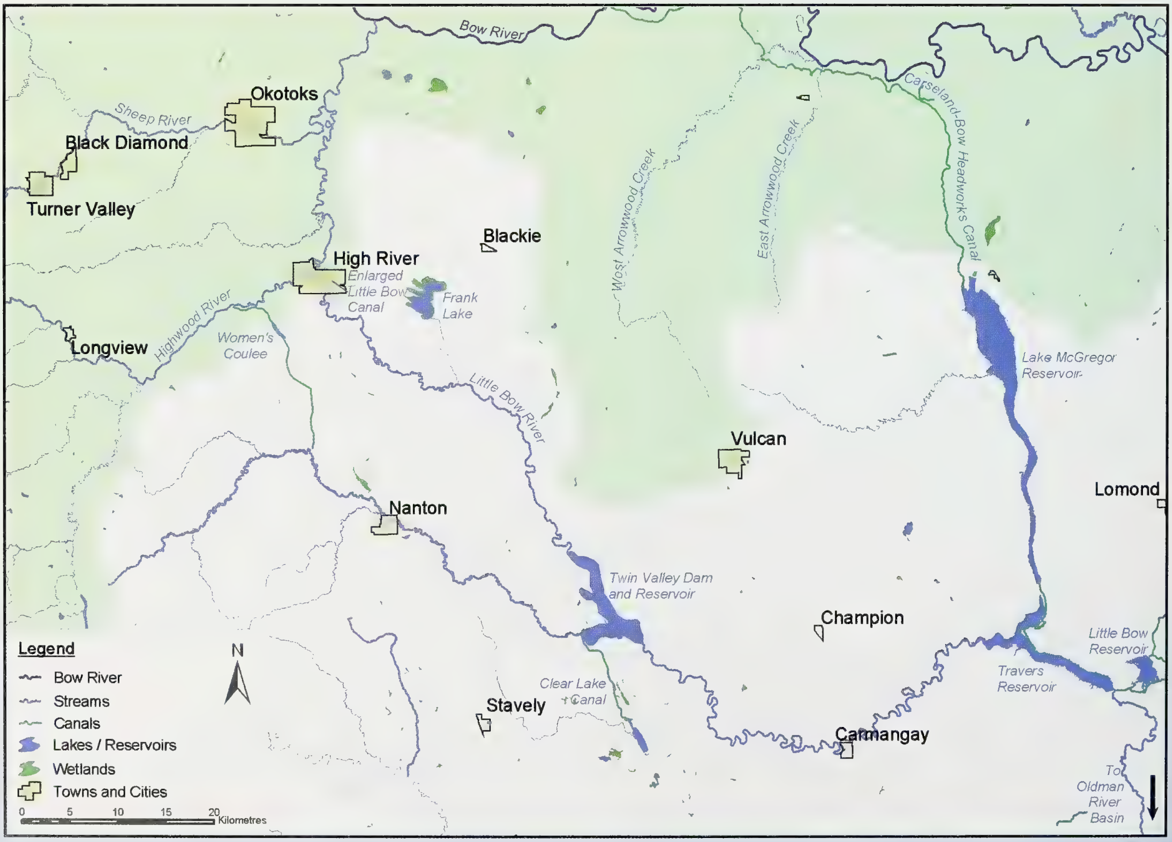
The most significant influence on the water quantity and quality in the Highwood River sub-basin is the Highwood Diversion, which has been in place for more than 100 years. The Highwood Diversion transfers water out of the Highwood River and into the Little Bow River sub-basin within the Oldman River Basin. Water demand in the Little Bow sub-basin often coincides with low flows in the Highwood River.[127] Low flow conditions caused by water diversions lead to high water temperatures and low oxygen concentrations, which may stress local fish populations.

The Little Bow Project / Highwood Diversion plan was proposed by Alberta Public Works, Supply and Services (now Alberta Transportation) in 1996. Water is diverted from the Highwood River down the Little Bow Canal into the Little Bow River.

The main goal of the project is to provide a reliable water supply for municipal and agricultural users in the Little Bow River sub-basin.[97] It would also change the timing of diversions from the Highwood River so that most would occur during spring high flow period and the water would be stored. This would lessen the demand on the Highwood River during low flow periods, including late summer. While the reservoir project was completed by 2002, the Highwood Diversion Plan has not yet been formally approved and is used as an interim plan.

The Highwood River Management Plan is being developed to address water issues in the Highwood River sub-basin. It includes aspects of water management relevant to the Highwood Diversion Plan as well as other water conservation issues. The Highwood River Management Plan is one of only two sub-basin water management plans to be developed within the Bow River Basin. The other is the Nose Creek Water Management Plan (see Chapter 6).

Figure 8.6 Highwood Diversion Plan[39]



Highwood Management Plan

For more than a century, water for agricultural, municipal, domestic, and industrial purposes has been diverted from the Highwood River sub-basin of Bow River to the Little Bow River sub-basin of the Oldman River. Water demand often coincides with low flows in the Highwood River and by the late 1970s competing demands had resulted in shortages for local water users and stress on the aquatic environment. This polarized the community on how best to operate and manage water diversions from the Highwood River into the Little Bow sub-basin and a moratorium limiting future water use licensing was instituted.

Through a planning process begun in the 1980s, the Government of Alberta developed the Little Bow Project/Highwood Diversion Plan to address the area's water management issues. The project proposal was to enlarge diversion structures and construct a new dam in the Little Bow sub-basin. The Little Bow Project/Highwood Diversion Plan (1995) included a set of priorities and operating rules for the existing and proposed water management structures in the basins. The operating rules are now referred to as the Highwood Diversion Plan (HDP). The structures include the existing Women's Coulee Diversion and Women's Coulee Dam, the expanded Little Bow Diversion, the new Twin Valley Dam (formerly the Little Bow Dam), and the new Clear Lake Diversion.

Spillway at Twin Valley Dam – AAFRD

The proposed HDP was reviewed at a joint federal/provincial review panel hearing in 1997 and 1998. At the conclusion of public hearings, the review panel found the proposal to be in the public interest but was not satisfied with all aspects of the plan. While approving the project, the review panel mandated a multi-stakeholder process to revise the diversion plan and develop a water management plan for the affected river basins. This led to the formation of a Public Advisory Committee (PAC) with representatives from all relevant stakeholder groups. The purpose of the new HDP is to develop a strategy for resolving water use issues within the Highwood River sub-basin (including the Little Bow, Mosquito, and Sheep sub-basins).

Consensus was achieved for a recommended diversion plan and future water management strategies. All structural components of the Little Bow Project have now been constructed and are in operation. Following public outreach activities, the PAC will submit its recommendations to Alberta Environment on a sustainable HDP. The recommendations of the PAC and the government's revised diversion plan will be submitted for approval in 2005. Future planning in the Highwood basin will deal with Water Conservation Objectives and the current moratorium on ***Water Act*** approvals within the framework of Alberta's Water For Life strategy.

Sheep River

The Sheep River is the main tributary to the Highwood River. It originates in the Highwood Range of Kananaskis Country. The Sheep River is 107 km in length and drains an area of 1,573 km^2. The confluence of the Sheep and Highwood rivers is east of the Town of Okotoks, about 13.9 km upstream of the confluence of the Highwood and Bow rivers. Like the Highwood River, its terrain is diverse and includes mountains, foothills, and prairie. Areas within the Sheep River are considered provincially significant.[237] Several parks and protected areas occur within the watershed of the Sheep River, including the Sheep River Provincial Park, the Elbow Sheep Wildland Park, and the Bluerock Wildland Park.

The Sheep River Provincial Park, which includes the former Sheep River Wildlife Sanctuary, is located about 25 km upstream of Turner Valley and extends for about 30 km along the Sheep River Valley. There are two campgrounds and many hiking and cross-country skiing trails. The park is at the intersection of the Rocky Mountain and parkland natural regions. The open grasslands and steep canyon walls of the valley provide important winter habitat for bighorn sheep and elk.[146]

A diversity of other wildlife is found within the park, including coyote, cougar, elk, deer, bear and Columbia ground squirrel. The park is also along a major migratory flyway for birds of prey. The golden eagle is the predominant species in these migrations, but the bald eagle, sharp-shinned hawk, northern goshawk, red-tailed hawk, and rough-legged hawk are observed as well.

The Sheep River provides habitat for mountain whitefish and bull, brook, rainbow, and cutthroat trout.[226] The mainstem and some of its tributaries are important spawning areas for rainbow trout; mountain whitefish also spawn in the mainstem Sheep River.

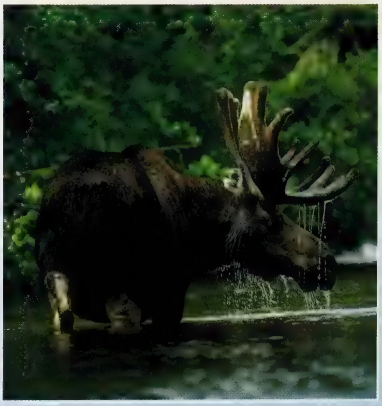
Upstream of Sheep Falls, the Sheep River was stocked with 8,400 cutthroat trout in 1971, but little evidence of their presence was found when a fisheries survey was conducted in 1980 and 1981. To determine whether the Sheep River upstream of Sheep Falls is capable of providing a viable fishery for cutthroat trout, 8,000 and 10,600 cutthroat trout were stocked above the falls in 2000 and 2002, respectively.[7,226] The river upstream of the Sheep Falls was closed to fishing to enhance their chance for survival. Current evaluations of the upper Sheep River fish stocks have yet to be completed.

The towns of Black Diamond, Turner Valley and Okotoks are located along the Sheep River. Due to its proximity to Calgary, Okotoks is experiencing an increase in commuter use and subsequent population growth. All these communities source their water from shallow groundwater wells adjacent to the river and discharge stormwater and treated wastewater into the river. Recent wells for Turner Valley and the Town of Okotoks are considered surface water withdrawals since they are hydraulically connected to the Sheep River.[193] The Town of Okotoks is currently monitoring the water quality of the Sheep River.

The towns of Black Diamond, Turner Valley and Okotoks have shown initiative and leadership in addressing watershed issues. The Town of Okotoks has developed "Sustainable Okotoks," which includes Municipal and Inter-Municipal Development Plans and a Water Management Plan. Okotoks is encouraging the establishment of a regional Sheep River Watershed Agreement, which includes planning guidelines for resource and land use.[235] Since 2002, the Towns of Black Diamond, Turner Valley and Okotoks have been working together to promote sustainability. They share a belief that water is an integral part of their


Cougar


Beaver


Moose

communities; they have formed a Tri Community Watershed Initiative to help manage their shared water resources. Activities include changing municipal policies, writing municipal water and river valley management plans, working with partners, hosting community events, engaging media, and assisting residents in water conservation efforts. To date, 100% of the households (more than 15,000 residents) have participated in community-wide water conservation campaigns that protect the local watershed.

The Initiative has improved local policy and decision-making through a collaborative multi-stakeholder approach. Involvement of residents, town councillors and stakeholders in watershed activities has allowed local decision-makers to gain awareness and strengthen community capacity. The Initiative is also ensuring that local choices are informed and reflect the collective beliefs of the community. By identifying values, engaging in local watershed activities and defining sustainability, the communities are able to monitor progress and feed into adaptive decision-making processes. The framework and best practices the towns have developed will be discussed as well as lessons learned.

Town of Okotoks Water Management Plan

The Town of Okotoks has initiated a planning process to identify the current and future water needs of the town. The planning process involved extensive public participation, including community-wide household surveys every three years. Okotoks' Municipal and Inter-municipal Development Plans and a Water Management Plan brought it recognition; it was one of the first communities in Canada to be identified as a "Sustainable Community."

The goal of the Okotoks Water Management Plan is to manage growth in the town to a limit of 25,000 to 30,000 people, within the carrying capacity of the Sheep River to supply potable drinking water and accept treated wastewater. The Water Management Plan is comprehensive and includes upgrades to the groundwater source wells and distribution system, improved wastewater treatment, water conservation (with a goal of reducing water consumption by 30%), watershed management, and aquatic monitoring. Community members assist with the monitoring program.

The upgraded wastewater treatment system includes an in-vessel sewage composting system that removes bio-solids and improves water quality of return flows. The town is currently planning for chlorine removal and nitrate reduction. Some of the many water conservation measures implemented by the town include mandatory metering of all water users, permanent outdoor watering regulations, with specified days and times from May to October, a low flow fixture by-law for new homes and renovations, low-flow retrofit of many town facilities, effective turf watering strategies for sports fields and green spaces, and research and demonstration sites for xeriscaping.

Monitoring program – M.Lynch

Okotoks has developed a River Valley Management Plan and is participating with Black Diamond and Turner Valley in a Tri Community Watershed Initiative. It also operates 10 water quality monitoring stations, located from the headwaters of the Sheep River to the confluence of the Highwood River. Okotoks is active in sharing the lessons they have learned through presentations to other municipalities, government agencies, non-profit groups, and stakeholders.

8.6 Where are we Headed?

Reach 6 of the Bow River was included as one of the high priority reaches in Phase 2 of the South Saskatchewan River Basin's Water Management Plan (see Chapter 2). Instream flow needs have been determined for several ecological criteria in Reach 6, including water quality, fish habitat, riparian vegetation, and channel structure.[90] After the Water Management Plan is approved, the Government of Alberta will set a Water Conservation Objective that will attempt to establish a balance between water consumption and environmental protection of the river, and determine the maximum amount of water that can be allocated.[24]

Pressure on water resources in Reach 6 is expected to increase in the future. Irrigation demands for water are already high and agricultural (stockwatering) and industrial users are expected to increase.[137] Predicted new water users include intensive livestock, small industrial and manufacturing operations. With an increase in livestock operations expected, management strategies for minimizing their influence on water quality and quantity will be important.

Municipal water use is expected to increase as populations grow. However, per capita consumption of water is expected to decrease as municipalities adopt water conservation and efficiency measures. In particular, the Towns of Okotoks, Black Diamond and Turner Valley have shown leadership in addressing municipal water management issues.

Due to the increasing pressures on water resources within Reach 6, it is important to collect comprehensive information on which to base predictions and make management decisions. While there is no hydrometric station directly measuring water quantity in this reach, flows can be calculated. Water quality monitoring is also conducted at one long-term river network site, just downstream of this reach. Wastewater treatment plants also monitor the quality of water discharged to the Bow River. These monitoring programs provide an excellent basis of information on the status of water quantity and quality along the mainstem of the Bow River in this reach.

The Highwood Management Plan, which includes the Highwood and Sheep river sub-basins, will be a key feature in resolving water issues within Reach 6. Information is lacking, however, on non-point sources of pollutants and land use impacts on water quality and quantity, particularly from agricultural production and intensive livestock operations. These data gaps represent opportunities to improve the understanding and management of the Bow River within Reach 6.

Chapter 9

Carseland Weir – R.Phillips

Chapter 9

Reach 7 – Carseland Weir to Upstream of Bassano Dam

9.1 What is in this Reach?

Within Reach 7, the Bow River winds its way through the prairie, east from the Carseland Weir, through the Siksika Reserve No. 146 (home of the Siksika Nation), to upstream of the Bassano Dam (Figure 9.1). Wheatland County is located on the north side of the river and Vulcan County on the south side of the river. The total length of Reach 7 is 126 km; it drains an area of 4,291 square kilometres (km^2).

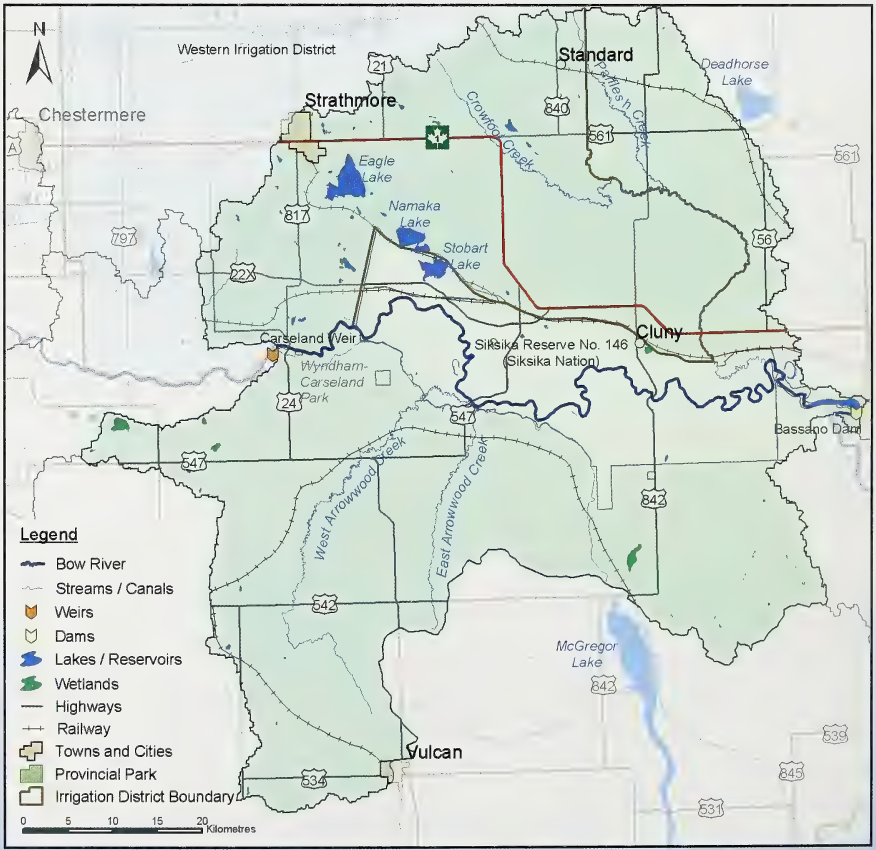
The main tributary to Reach 7 is Crowfoot Creek, which enters the river from the north near Bassano. West Arrowwood Creek, the second largest tributary, enters the river from the south near the town of Arrowwood. Eagle, Deadhorse, Namaka, and Stobart lakes are natural bodies of water.

The watershed of Reach 7 is located within the grassland natural region, characterized by mixed grass vegetation and a low relief landscape.[228] Mammals include mule and white-tailed deer, pronghorn antelope, coyote, fox, white-tailed jackrabbit, and Richardson's ground squirrel. The most common birds are sparrows, larks, longspurs, falcons, northern harriers, and hawks.[57,223] The watershed also provides important habitat for snakes, frogs and salamanders.

The Bow River flows through a wide floodplain in Reach 7. Wetland habitat is limited due to the steep riverbanks, but the floodplain supports dense riparian poplar forests. The vertical cliffs also provide nesting habitat for falcons and geese and staging habitat for a variety of birds. Waterfowl, including mallards, scaups, redheads, canvasbacks, pintails, shovelers, tundra swans, pelicans, and blue-winged, cinnamon and green-winged teals, are common on the prairie wetlands.[3,52]

Water quality is generally good, however, nutrient concentrations are elevated and pesticides are detectable within this reach. A transition from cold-water fish habitat to cool-water fish habitat occurs in this reach. The most common fish species in the upper part of the reach include mountain whitefish, rainbow trout, brown trout, longnose sucker, and white sucker.[197]

Figure 9.1 Overview of Reach 7[7,16,39,45]

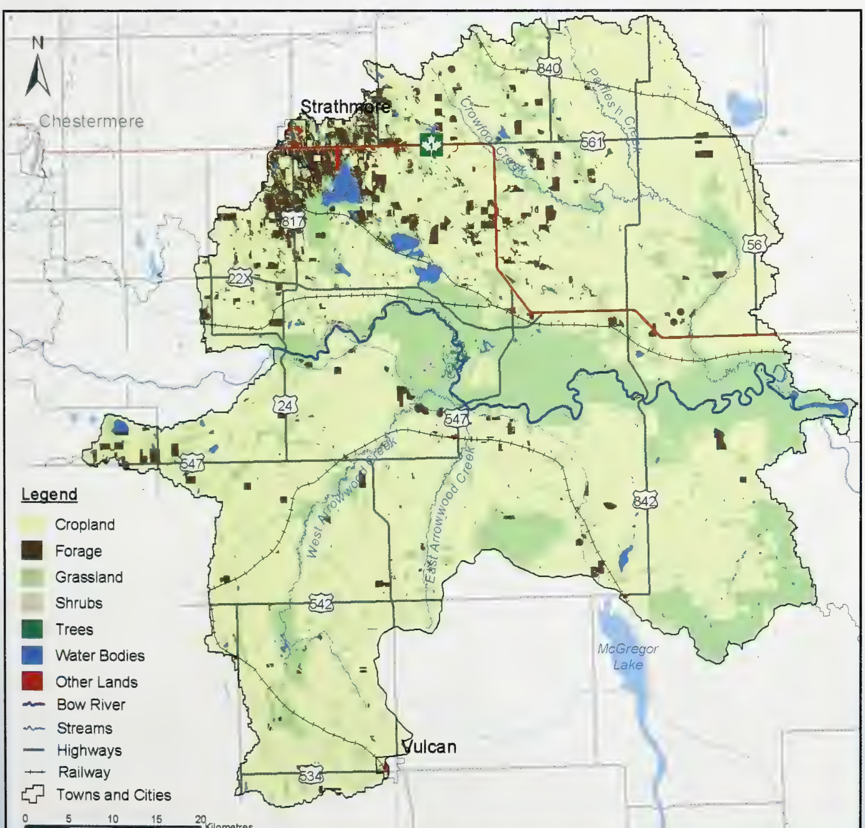


Northern pike and burbot are found occasionally in the upper part of the reach. In the impounded area upstream of the Bassano Dam, northern pike are the most common sportfish species.

In 2002, the human population was about 17,500.[36] The largest communities are the Town of Strathmore and the Siksika Nation. Strathmore doubled in population between 1991 and 2003, from 4,185 to 8,640, and the population of Wheatland County has grown by about 35%, from 5,779 to 7,889. The population of the Siksika Nation (2,770 in 2001) has not changed measurably in recent years.

The greatest consumptive use of water in this reach is from the Carseland Weir at the upstream end. The weir is the headworks for the Bow River Irrigation District (BRID). Water is withdrawn at the weir and transferred through a series of canals and reservoirs to the BRID, which covers the western portion of the landbase of Reach 8 (see Chapter 10). The WID, which withdraws water from Reach 5, covers some of the landbase of Reach 7.

Figure 9.2 Land use of Reach 7[7 39 45]



Therefore, water withdrawals for the BRID are discussed in this chapter, but the land use impacts are discussed in Chapter 10. Similarly, the water withdrawals for the WID are discussed in Chapter 7, while its land use impacts are discussed in this chapter. See Figure 2.6 for a map of the irrigation districts.

Agriculture is the main land use and features dryland and irrigated crops, livestock operations and feedlots. Livestock operations are primarily cattle and chickens, with some pig and sheep farms.[137] The WID occupies the northern side of the Bow River, northwest of Crowfoot Creek. Irrigated crops grown in the WID include forages, cereals, and lesser amounts of oil seeds and specialty crops.[246]

There has been an increase in oil and gas exploration and development in recent years that is likely to continue into the future.[117] Along with Reach 8, the watershed of Reach 7 has the highest oil and gas development in the Bow River Basin.

9.2 Hydrology

The natural flows of the Bow River in Reach 7 are illustrated in Figure 9.3, which shows the average weekly discharge of the *Bow River below the Carseland Weir* (Figure 9.5, page 149). Natural streamflows peak in early June at an average of 375 cubic metres per second (m^3/s). Natural baseflows, which consist mainly of groundwater, occur from December to March and average around 30 m^3/s.

The average recorded flows (Figure 9.3) show the modified flow regime that results from upstream hydroelectric dams and water withdrawals, including those of the BRID. Compared to natural flow data, the average recorded spring discharge peaks have decreased to about 260 m^3/s, while baseflows have increased to an average of about 60 m^3/s.

How do Water Withdrawals Affect Hydrology?

The water withdrawals within Reach 7 are cumulative with those from upstream reaches and have resulted in substantial changes to the natural flow regime of the Bow River. Table 9.1 outlines the Bow River water licence allocations in Reach 7 for 2002, as provided by Alberta Environment. The total volume of water licensed for diversion by all users was more than 569 million cubic metres (m^3) in 2002. These diversions represent about 14% of the long-term average flow for the *Bow River below the Carseland Weir*. Almost 99% of the total allocation within Reach 7 is for irrigation and agricultural purposes.

The BRID is the largest of the irrigation/agricultural licences, with 98% of the total allocation (Table 9.2). The majority of the withdrawals occur during the spring, when flows are naturally higher, and are stored in the reservoirs. The BRID returns about 30% of its licensed consumption to the Bow River; it is difficult to determine the return flows provided by the smaller irrigation licensees.

In 2002, just over 1% of licensed water withdrawals in Reach 7 were for uses other than irrigation and agriculture. Industrial uses include food processing, oil field injection, concrete manufacturing, and aggregate operations. None of the water withdrawn for industrial purposes is returned to the river.

All the communities get their domestic water supplies from shallow groundwater wells or irrigation canals, rather than directly from the Bow River.[117] The Villages of Arrowwood, Cluny, Hussar, and Carseland use shallow groundwater. The Towns of Standard and Strathmore use water from the WID canal system. The Town of Gleichen also draws its water from an irrigation canal within the WID.

Return flows from communities to the Bow River are very minor. Instead of discharging to the Bow River, Strathmore and Gleichen treat and re-use their wastewater for irrigation purposes. Arrowwood, Carseland, and Cluny discharge stormwater and treated wastewater to the Bow River. Standard discharges its treated wastewater to Crowfoot Creek, the major tributary of the Bow River in this reach. However, wastewater discharges from all four communities are small in volume and occur once a year or less.

Table 9.1 Licensed allocation of the Bow River in Reach 7 (2002)[108 193]

Water User	Annual Licensed Allocation (m^3)	Percentage of Annual Average Bow River Discharge (%)[a]
Industrial	3,198,400	0.08
Irrigation & Agriculture	563,829,493	14.27
Municipal	1,899,800	0.04
Other	262,384	< 0.01
Total	**569,190,077**	**14.41**

[a] Average annual natural discharge (1912-2001) of Bow River below the Carseland Weir is 3,949,611,434 m^3

Figure 9.3 Discharge of the Bow River below Carseland Weir (1971 – 2001)[29]

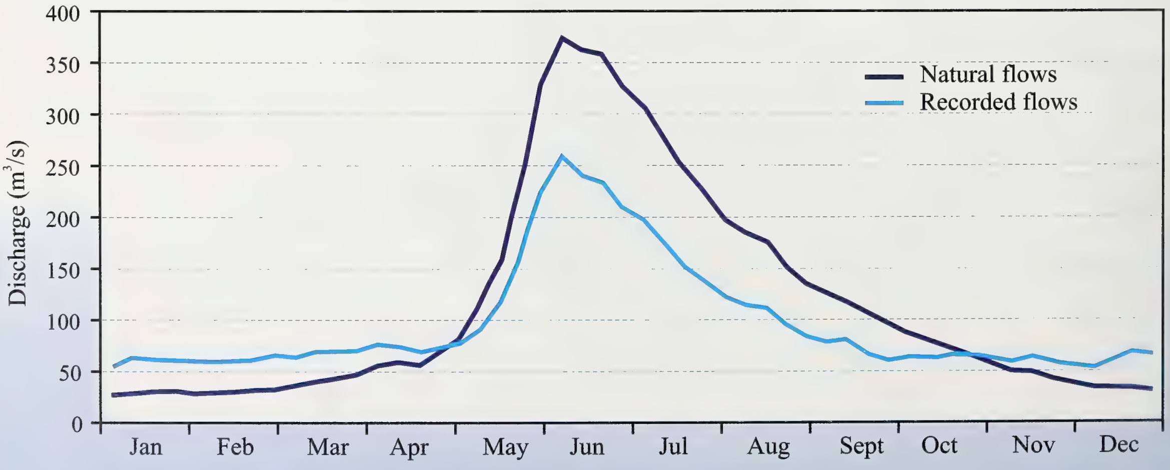


Table 9.2 Licensed and estimated annual consumption and returns to the Bow River in Reach 7 (2002)[193]

Water User	Annual Consumption from the Bow River (m³)		Annual Return Flows to the Bow River (m³)	
	Licensed	Estimated[a]	Licensed	Estimated[a]
Industrial	3,198,400	1,228,075	0	0
Irrigation & Agriculture	440,481,293	327,544,873	123,348,200	78,449,445
Municipal	1,070,882	766,222	828,918	223,270
Other	262,384	262,384	0	0
Total	**445,012,959**	**329,801,554**	**124,177,118**	**78,672,715**

[a] When water use reports for each license are absent, the licensed consumption and licensed return flows are used to approximate the estimated consumption and return flows, respectively. This likely overestimates the estimated consumption and return flow data in this reach

Several communities in the watershed of Reach 8, including the Town of Vauxhall, the Villages of Lomond and Milo, and the Municipal District of Taber, draw water from the BRID canals, which in turn take water from the Carseland Weir. As a result, their licences are accounted for in Reach 7 water allocations. While the water for these communities is carried by the BRID canal system, their use is calculated separately from the BRID allocation. Some of the water allocated for municipal diversions in 2002 was returned to the Bow River, via the BRID channels, in the form of treated effluent discharges. As well, some of the return flows from municipalities that withdraw from the BRID, such as Vauxhall, are transferred to the Oldman River Basin via BRID canals.[137]

The "other" Reach 7 water licences include golf courses, recreation areas and a resort. With the exception of the Carseland Golf Course, which draws water directly from the Bow River, these facilities use water from BRID canal system. Water use by these facilities is consumptive, with no water being returned to the Bow River in 2002.

Flow metering on Crowfoot Creek – AAFRD

How does Land Use Affect Hydrology?

Approximately 292,000 ha (about 66%) of the landbase is in agricultural cultivation (Figure 9.2). Both irrigated and dryland crops are grown, with forage crops comprising the largest area. Alfalfa for hay and barley for silage are the principal forage crops.

Where it exists, irrigation is administered largely through the WID, which overlaps part of the landbase of Reach 7. About 60% of the WID land lies in the Bow River Basin, with the other 40% in the Red Deer River Basin. In the last few decades, an increasing proportion of land in the WID has become urbanized, especially on the western side (Reach 5), where the City of Calgary and bedroom communities have expanded. Agriculture remains the most important land use on the drier, warmer, eastern side of the WID (Reach 7).

In this portion of the reach, agriculture is more intensive and relies more heavily on irrigation water. It is interesting to note that the climate varies considerably between the western (Reach 5) and eastern sides (Reach 7) of the WID, especially in terms of heat, frost free days, and to a lesser extent, precipitation.[8]

The WID includes approximately 38,600 ha, but in most years, only about two thirds are irrigated. Cereals account for about 28% of crop production in the WID, with approximately 60% grown under irrigation.[10] Where irrigation is not available, cereals play a larger role. Barley (for livestock feed), prairie spring wheat and hard spring wheat are the most significant cereal crops in both the dryland and irrigated portions. In wetter years, a substantial portion of the irrigation water allocated to these crops is not used.[229]

Approximately 118,000 ha (about 32%) of the landbase is grassland, much of which is used as pasture. The livestock population within Reaches 7 and 8 is likely higher than in other Bow River reaches and use of grasslands for pasture is common.[137] The largest livestock operations are for cattle and chickens, but pig and sheep operations also exist. Secure water supplies, as well as feed sources, have led to the growth of the livestock industry in the area in the last decade and to expectations that this sector will continue to grow. The area east of Strathmore is ideally situated for further livestock development due to its proximity to existing packing plants in Calgary and Brooks.[188] Unfortunately, there is no site-specific data on the impacts of these land-use practices on water quantity (see Chapter 2).

Agricultural development has led to the drainage and conversion of wetlands, though, it is important to note that wetland habitat has also been created, as part of the irrigation system. There is no site-specific information on how changes in the area and type of wetlands have affected water quantity in Reach 7.

The BRID Conveyance System

The BRID conveyance system consists of a series of canals, pipelines and reservoirs. Approximately 25% of the more than 1,000 km BRID system consists of buried pipeline, which reduces evaporative losses and operational spills. Water for the system is withdrawn from the Bow River at the Carseland Weir, then flows via a provincially-owned headworks canal, to the Lake MacGregor, Travers and Little Bow Reservoirs. The BRID system begins at the outlet from the Little Bow Reservoir and splits into two canals soon after. The northern Lomond Canal flows into the Badger Reservoir and services lands around Lomond and Enchant. A canal from the Badger Reservoir flows southeast and ends at Lost Lake. The system eventually drains into the Bow River in Reach 8.

The southern Main Canal and the associated Scope Reservoir irrigate land to the south and east, including areas around Enchant, Vauxhall and Hays. Though much of the BRID itself is located within the Oldman River Basin, only small percentage of the land drains into the Oldman River. The majority of these lands drain into the lowest reach of the Bow River. However, both the Oldman and the Bow River converge a short distance downstream to form the South Saskatchewan River, and these flow transfers are of little consequence.[190]

MacGregor Canal Head - R.Wolfe

9.3 Water Quality

Though water quality of the Bow River is generally good, nutrient concentrations are elevated and some pesticides are detectable. The most significant point source influences on the water quality in Reach 7 are the City of Calgary's Bonnybrook and Fish Creek wastewater treatment plants (WWTPs), located upstream.[249] Over the past 20 years, the City of Calgary has performed numerous upgrades to its wastewater treatment capacity and has greatly reduced suspended solids, organic material, bacterial, and nutrient loading to the Bow River.[203 216]

All the communities use lagoons for wastewater treatment, and only a few of them discharge stormwater or wastewater directly into the Bow River. Hence, these communities have relatively little impact on the water quality in Reach 7.

Surface water runoff from agricultural cropland, feedlots and pasture is another influence in this reach. These non-point source influences are difficult to quantify, but some specific information exists regarding their impact on water quality, particularly in the Crowfoot Creek area (see Section 9.5).

Water Quality of the Bow River at Cluny

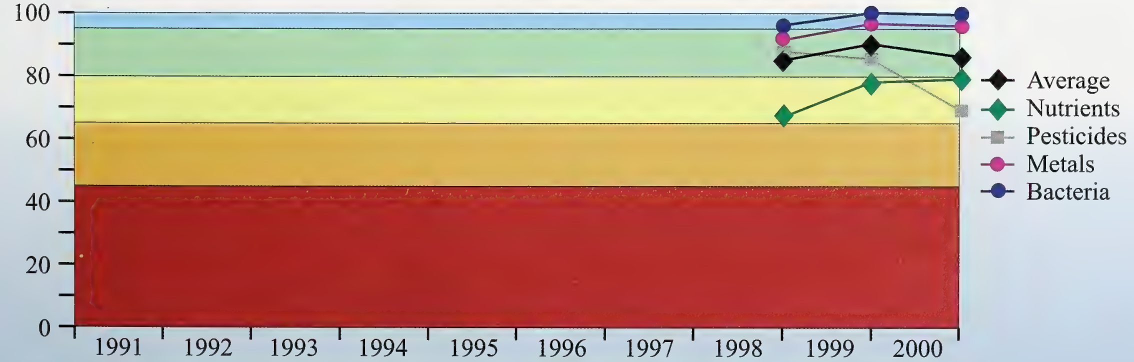
Water quality in this reach of the Bow River is measured by Alberta Environment. The station was dropped from their long-term river network (LTRN) monitoring program in 2002, but may be reinstated in the future. The site is named *Bow River at Cluny* (AENV LTRN Site 00AL05BM3300) and is located mid-reach, where Hwy 842 crosses the Bow River, about 77 km east of the upstream end of the reach (Figure 9.5). Crowfoot Creek, the main tributary in Reach 7, enters the Bow River 29 km downstream of this monitoring site. Hence, any influences on water quality of the Bow River from Crowfoot Creek are not included in this station, but would be reflected in downstream monitoring sites (see Chapter 10).

Recent water quality assessments of data collected at this site include the determination of Water Quality Indices (WQI) for several suites of key variables, including metals, nutrients, bacteria, and pesticides. The WQI has been calculated at this site since 1998 (Figure 9.4). An overall average WQI has also been generated for this site based on the results of these suites of variables.[27] The averaged WQI for the site rated the water quality as good from 1998 to 2001.

Nutrients rated fair throughout the period of record, with both nitrogen and phosphorus exceeding water quality guidelines for the protection of aquatic life. Total nitrogen regularly exceeded the water quality guideline, but only during the winter months. During the summer months, uptake by aquatic plants may play a role in lowering the total nitrogen concentrations in the water. Total phosphorus also regularly exceeded the water quality guideline, but no seasonal patterns were evident. These exceedences suggest that nutrient enrichment has increased the productivity of the system and altered the aquatic community.

Synoptic surveys of the Bow River indicate that in this reach, the Bonnybrook and Fish Creek WWTPs are the largest point sources of nutrients. There was a trend toward improvements in nutrient concentrations over the three years of record, which may be linked to improvements in nutrient removal at the City of Calgary's WWTPs. However, these improvements in wastewater treatment will probably be offset by future population growth, with an overall result of increased nutrient loading to the Bow River.

Figure 9.4 Canadian water quality index for the Bow River at Cluny[27]



Pesticides rated as good for 1998/1999 and 1999/2000, but declined to fair in 2000/2001 due to higher concentrations of detectable pesticides. While most samples were below the detection limits, a few had detectable concentrations of 2,4-D, MCPP, atrazine, chlorpyrifos, MCPA, and diazinon. 2,4-D and MCPP were the most commonly detected pesticides. 2,4-D is used to control broadleaved weeds on agricultural, pasture and urban lands; MCPP is more commonly used for cosmetic lawn purposes.

MCPA, which is used to control broadleaved weeds in cereals and grassland, was found to occasionally exceed water quality guidelines for irrigation, livestock watering and the protection of aquatic life throughout the sampling period. On one occasion each, atrazine and chlorpyrifos exceeded water quality guidelines for the protection of aquatic life. Atrazine, which is used to control broadleaved weeds in crops, also exceeded the irrigation and livestock watering guidelines on one occasion. Agricultural use of the insecticide chlorpyrifos is generally restricted to years in which insect outbreaks occur.[30] In 2000, chlorpyrifos was banned from residential use in Canada.

One year's worth of data is not enough to suggest that concentrations of pesticides are increasing at this site, but it does point to the need to closely monitor water quality and improve pesticide management. The results may be influenced by the focus on spring and summer sampling in the later years, compared to year round sampling in the earliest year. Pesticide levels are related to both municipal and agricultural use.

Improved pesticide ratings may occur in the future if Calgary and other communities continue to discourage residential use of pesticides and commit to ending their cosmetic use on lawns and parks. While likely a smaller influence relative to municipal use, pesticide levels are also related to surface runoff from agricultural crops, which cover approximately 66% of the landbase.

Bacterial concentrations within Reach 7 rated excellent from 1998/1999 to 2000/2001. Both fecal coliform bacteria and *E. coli* were consistently below guidelines, with the exception of one sample in 1998 that exceeded the irrigation guideline.

Synoptic surveys of the Bow River in the mid-nineties indicate that fecal coliform loading in the Bow River was primarily due to point sources.[249] Major point sources of fecal coliforms include the Bonnybrook and Fish Creek WWTPs. Non-point sources such as agricultural runoff are not easily quantified, but likely contribute to the bacterial concentrations in the river.[203]

The improved bacterial ratings in the late-1990s, evident in longer-term data from sites upstream and downstream of Reach 7, are likely due to improvements in disinfection and wastewater treatment by municipalities discharging into the Bow River.

The rating of metals improved from a good rating in 1998/1999 to excellent ratings since. In 1998/1999, samples of copper and nickel exceeded the water quality guidelines for the protection of aquatic life on one occasion each. Lead and cyanide were found to exceed water quality guidelines for the protection of aquatic life once each in 1999/2000 and 2000/2001, respectively. These slightly elevated concentrations occurred occasionally, were transient and were of no concern for long-term water quality or aquatic organisms. The sources of these metals include wastewater effluent from Calgary and natural tributary sources.[249]

WID Water Quality Study

In addition to water quality monitoring undertaken by Alberta Environment, the WID has conducted water quality sampling. From 1996 to 1999, spring and summer samples were tested at thirty-two sites throughout their distribution system. In general, water quality decreased from upstream to downstream along the canals. Total phosphorus, dissolved phosphorus and conductivity were generally lower upstream. Higher concentrations of nitrate+nitrite were measured in the canal upstream of Chestermere Lake. Concentrations of fecal coliform bacteria and *E. coli* increased gradually downstream. However, concentrations of metals tended to decrease from upstream of Chestermere Lake to downstream of the lake, supporting the theory that these metals come from stormwater or upstream WWTPs.

In general, water quality at the canal sites was more frequently in compliance with water quality guidelines than at Weed or Eagle lakes. The WID's monitoring program has since been reduced to a basic long-term program at six sites along the canals.

9.4 Ecosystems

Terrestrial Habitat

The landbase of Reach 7 is located entirely within the grassland natural region.[19] Natural sub-regions include foothills fescue, northern fescue, mixed grass, and dry mixed grass (Table 9.3 and Figure 9.5).

The mixed grass sub-region covers most of the landbase, including most of the floodplain of the Bow River. The landscape of the mixed grass sub-region is mainly low relief. The moister, cooler conditions of this sub-region, compared to the dry mixed grass sub-region in Reach 8, are reflected in the greater productivity of the rangelands and typically produce 25% more biomass.[19]

The dominant native plants in this sub-region include spear grass, western porcupine grass, western wheat grass and northern wheat grass. On drier, exposed sites, blue grama grass is more common. Typical vegetation of sandy areas includes a variety of grasses, as well as low shrubs such as silverberry, western snowberry, and prickly rose.

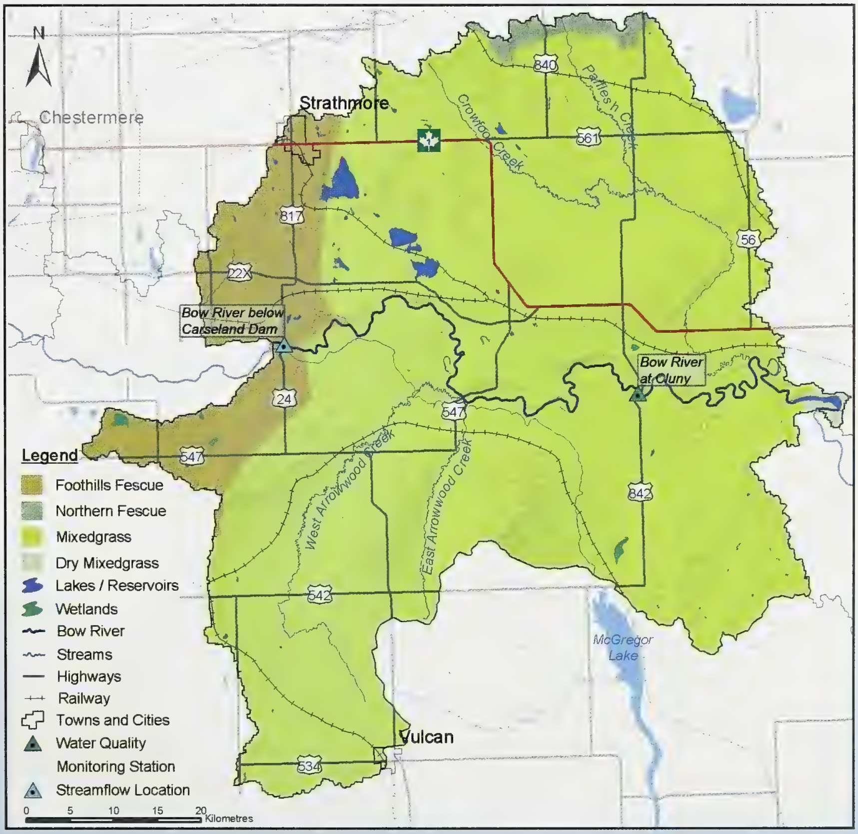
A small portion of the upstream edge of the watershed is located in the foothills fescue sub-region. Native vegetation in the foothills fescue is characterized by grass species such as fescue and oatgrass,[19] and a variety of native flowering plants and herbs. Shrubby cinquefoil is common in well-drained areas where grazing pressure is high. Deciduous shrub and tree communities develop where water is locally more abundant, particularly along the rivers, adjacent to older irrigation canals, around the margins of lakes, and on north-facing slopes.

A narrow band along the northern edge of the watershed occurs within the northern fescue sub-region. Grass species include rough fescue and Hooker's oatgrass. The easternmost portion of the landbase is located in the dry mixed grass sub-region, which is described in Chapter 10.

Table 9.3 Size and extent of Reach 7 features[23 39 40 45 195]

Feature	Area (km^2)	Extent of Area (%)
Foothills fescue sub-region	468.2	10.91
Northern fescue sub-region	43.3	1.01
Mixedgrass sub-region	3,700.8	86.25
Dry mixedgrass sub-region	10.5	0.24
Lakes	30.3	0.71
Reservoirs	5.9	0.14
Lagoons	0.5	0.01
Wetlands	13.0	0.30
Rivers	16.5	0.39
Canals	1.5	0.04
Total	**4,290.5**	**100.00**

Figure 9.5 Natural sub-regions and measuring locations of Reach 7[23 39 40 45 195]



Agricultural activities have influenced vegetation communities and, in turn, wildlife distribution. Much of the native grassland is in cultivation (66%) and a large portion of the remaining grassland (27%) is used for grazing. Animals and birds are common throughout this but animals and birds are common. The most common birds are sparrows, larks, longspurs, falcons (prairie, kestrels and merlins), northern harriers and ferruginous, red-tailed and Swainson's hawks.

Horned lark, McCown's longspur, chestnut-collared longspur and Richardson's ground squirrel are common in heavily grazed areas, while Baird's sparrow, Sprague's pipit, sharp-tailed grouse, and upland sandpiper occur in lightly grazed areas that are more representative of native grasslands. Western meadowlark, kingbirds and white-tailed jackrabbit tolerate a range of grazing conditions and occur throughout the watershed of this reach.

Sagebrush flats are a unique habitat type within the grassland natural region and provide important habitat for lark bunting, Brewer's sparrow, other songbirds, and pronghorn antelope. Other mammals in the area include mule and white-tailed deer, coyote and fox.

Important habitat is also provided for bull snakes and garter snakes, salamanders, northern leopard frog and chorus frogs. The northern leopard frog is considered “at risk” in Alberta (see Chapter 2).[44]

Riparian and Wetland Habitat

In Reach 7, the Bow River meanders through a broad floodplain, between 500 and 2,500 m wide.[90] As in Reach 6, the riverbanks are relatively steep, with vertical cliffs in some areas. The floodplain contains the largest and most dense stands of poplar along the Bow River Valley. Conifers are found along the north-facing slopes, and shrubs and grasses along the more arid south-facing slopes. Human activity within the floodplain is minimal and includes a golf course and some agricultural activity, particularly grazing. The floodplain is primarily influenced by changes to the natural flow regime.[123]

Balsam poplar is the dominant riparian tree species in the upper part of the reach, while plains cottonwood is dominant in the lower part of the reach.[90] Hybrids occur where the ranges of these tree species overlap. Riparian forests are dependent on flooding for the recruitment of new saplings; the magnitude of the floods as well as their timing and pattern are important.[201] Since the 1930s, cottonwood recruitment has been low, with only a few minor recruitment events. This is likely due to flow regulation and drier climatic conditions throughout the basin.

Riparian health was assessed by the Cows and Fish Program, which found this reach to be healthy, but with problems.[38] A high percentage of disturbance-caused plants and invasive plant species were found. Common invasive plant species along Reach 7 include Canada thistle, common tansy, scentless camomile, perennial sow thistle, and leafy spurge. Native grass cover was considered poor to moderate. Shrub cover was high, with light browse, indicating that recent management of livestock grazing is not negatively affecting regeneration of shrubs. However, a large percentage of the shrubs were grazing-resistant species such as buckbrush and wild rose, which may reflect previous impacts from grazing.

Ferruginous hawk – A.MacKeigan

Mallard duckling – A.MacKeigan

Immature Swainson's hawk – A.MacKeigan

Cottonwood recruitment

Riparian poplar forests (cottonwoods) provide many important functions including wildlife habitat and corridors, livestock shelter, resources for the aquatic food web, and buffer zones to maintain water quality.[illegible]

Cottonwoods require specific timing and flood flow conditions for successful recruitment.[illegible] Spring flood flows must occur shortly before seed release so the seeds are released as the flood flows are beginning to recede. Flood flows must be between 50 and 150 centimetres (cm) above the baseflow level of the river; high enough to flood the banks of the river and leave behind sediment deposits at the appropriate bank height for the riparian poplars to establish. The flows need to recede slowly, less than 2.5 cm per day is favourable, so that the seedlings' root zones can become established. If flows recede from 2.5 to 5 cm per day, the seedlings become drought-stressed; more than 5 cm per day is lethal. In the following year or two, there needs to be no flood flows so that the seedlings can fully establish.

Balsam poplar decline (RiverWatch Science Beyond Banks)

Studies have demonstrated the effect of flow regulation on cottonwood recruitment in the lower Bow River, Kootenay and St Mary rivers.[illegible] For the lower Bow River, the effects of flow regulation on channel dynamics and riparian poplar density were assessed by the number of ageing trees and by comparing 1918 land survey maps with air photos from 1950, 1991 and 1992. The study indicates that flow regulation has resulted in channel stabilization, hence fewer recruitment areas, and that only a few minor recruitment events have occurred since the 1930s. To a certain extent, flows contributed from the Highwood River have moderated these effects along the Bow River.

Although some cottonwood regeneration occurs through suckering, seedlings are needed to maintain genetic diversity and replenish the forest density. Though the riparian forest density is currently similar to what it was in the late 1800s, it is estimated that the forest could be gone in the next 100 to 150 years if significant recruitment does not occur.[92] The South Saskatchewan River Basin IFN study has determined instream flow recommendations for cottonwood forests in Reaches 5, 6, 7 and 8 of the Bow River.[90] An evaluation of the effect of changing instream flow regulations on the St. Mary River in southern Alberta indicates that re-establishment of flood flows and natural patterns can have positive effects on cottonwood recruitment.[199]

Ducks Unlimited Canada - Namaka-Stobart Lakes Project

The Namaka-Stobart wetland complex and associated uplands function in a number of ways to restore wildlife habitat. Both Namaka and Stobart Lakes provide important shelter habitat for thousands of flightless waterfowl during the critical mid-summer moult period. Over the years, a total of 311 ha of uplands have been restored to a mix of tame and native forage at Namaka Lake. These uplands provide wildlife cover around the wetland, with only occasional management through grazing or haying.

Since its initial wetland restoration in 1949, the project has evolved to include improved water supply and management, and the restoration to grassland vegetation of the uplands around Namaka Lake. Over the years, fluctuating water levels have occasionally flooded out nesting birds and adversely affected emergent vegetation. During the late summer, declining water levels and resultant stagnation often resulted in toxic blue-green algal blooms and avian botulism, occasionally causing the deaths of thousands of birds. In 2000, the inlet supply was rerouted using spill water from the WID to reduce potential disease problems for wildlife. Changes were also made to the outlet control and channel to improve summer water circulation and late summer water quality in Stobart Lake, as well as the quality of the water spilling to the Bow River.

Partners in this project have included Ducks Unlimited Canada, Alberta Sustainable Resource Development, Alberta Environment, the Western Irrigation District, and the Siksika Nation.

Stobart Lake Project - T Sadler

The riparian area provides high quality wildlife habitat for sharp-tailed grouse, pheasant, grey partridge, coyote, fox, mule and white-tailed deer.[57 228] Mature trees provide nesting habitat for ferruginous, red-tailed and Swainson's hawks and there are at least two great blue heron rookeries. The riparian forest provides pileated woodpecker habitat and there is a high diversity of breeding birds.[228] Non-breeding white pelican and double-crested cormorant, likely from Lake Newell, feed in the area just upstream of the Bassano Dam in summer and early fall.[57]

Wetland habitat along the Bow River is limited, due to the steep banks, but the cliffs provide some nesting sites for geese and falcons. Feeding habitat and staging areas for geese and ducks are also found.[57] Namaka and Stobart Lakes provide habitat for non-breeding Western grebe and are considered environmentally significant areas of national importance.[228] These lakes are also regionally important staging areas for ducks, geese and shorebirds.

The irrigation water withdrawals at the Carseland Weir help to support more than 12,000 ha of wetland habitat (including storage reservoirs) within the BRID. Since the BRID is located in Reach 8, these wetlands are discussed in Chapter 10.

Aquatic Habitat

Within Reach 7, a transition from cold-water to cool-water fish habitat occurs, and limits to salmonid distribution begin. The Bow River recreational trout fishery extends approximately to Cluny. In the upper part of the reach, mountain whitefish, rainbow trout, brown trout and longnose and white sucker are the most common species.

Important rainbow and brown trout spawning areas are located immediately downsteam of the Carseland Weir, and mountain whitefish spawn throughout the reach. Northern pike and burbot are found in the upper part of the reach, but are more common downstream in the cool-water habitat. Northern pike are the dominant sportfish species in the Bassano Reservoir.[197]

Effects of canals and irrigation withdrawals on fish

Fish enter many of the Irrigation District canals either from reservoirs within the irrigation system or from the Bow River during water diversions. When irrigation water is diverted from the Bow River, small fish are entrained or drawn in to the irrigation canals. The largest numbers of entrained fish are young-of-the-year mountain whitefish and sucker species.[illegible] Rainbow and brown trout are also entrained.

In the fall, water withdrawals are discontinued for the year and the irrigation canals are allowed to drain. During this time, many fish in the canals move into existing reservoirs, but some become stranded in the canal system. Although the canals are allowed to drain, pockets of standing water, some more than a metre deep, are found throughout the canal system. Monitoring by the WID found that the most common stranded species were longnose sucker and northern pike, with smaller numbers of mountain whitefish, rainbow trout, brown trout, yellow perch and spottail shiner. In most cases, the water in these ponds is too shallow to provide adequate overwintering habitat, and it is assumed that the majority of stranded fish die during the winter. Alberta Sustainable Resource Development issues fish salvage licences, and in some cases, stranded fish are harvested for consumption.[48]

Monitoring data are limited and further work is required to determine whether fish entrainment or stranding has an impact on fish populations of the Bow River or irrigation reservoirs. Potential management options described in recent WID monitoring reports include:[48 49]

- Implement fish exclusion structures at the water diversion structures on the Bow River and/or at outflows of reservoirs
- Eliminate deep pool habitat within the canal system
- Rescue fish from pools and re-release them back into the Bow River
- Provide a flushing process to herd fish into deeper water bodies

The warmer water temperatures and enhanced nutrient content in this reach affect aquatic habitat and production. Nutrient enrichment from Calgary's WWTPs continues to influence the downstream reaches, and has led to increased growth of algae and aquatic plants. Since the installation of enhanced nutrient removal at the WWTPs throughout the 1980s and 1990s, productivity has decreased. Declines in algae growth at Cluny were found following reductions in nitrogen loading from the WWTPs.[216]

The presence of dams and water control structures influences the movement of fish within the Bow River system. The Carseland Weir, which is at the upstream end of Reach 7, was previously a barrier to fish movements. Alberta Transportation refurbished the weir and its associated fishway in 2003 and 2004. Subsequent monitoring indicates that mountain whitefish and rainbow and brown trout now successfully use the fishway.[197] The Bassano Dam at the eastern end of Reach 7 is a physical barrier to upstream fish movements, but not to downstream movements.

Deadhorse Lake does not have an outlet and as a result, water quality and aquatic habitat is generally poor. Namaka, Stobart and Eagle Lakes have outlets, but can become stagnant, with little flow-through during dry years. Regardless, Eagle Lake has a small reproducing walleye population and also contains northern pike.[197]

9.5 Tributaries

Crowfoot Creek

The main tributary to the Bow River within Reach 7 is Crowfoot Creek. Other creeks, including West Arrowwood Creek, are intermittent. Crowfoot Creek enters the Bow River from the northeast, originating in and flowing through grasslands. It is 141 km in length and drains an area of 1,438 km. It has two main tributaries, North Crowfoot Creek and Parflesh Creek. The Village of Standard is located in the upper reaches of North Crowfoot Creek.

Crowfoot Creek is located within the WID. It is naturally an intermittent stream, but return flows from the WID now add to the natural flows. Fish habitat is limited, however, northern pike use bank-flooded areas with emergent vegetation for spawning.[197]

Land use within the Crowfoot Creek sub-basin includes ranching and oil and gas operations. The sub-basin is an area of intensive agricultural activity, including feedlots and other livestock operations, as well as crop production. The effects of these land uses on the water quality in Crowfoot Creek have been assessed through several studies.

The water quality of Crowfoot Creek, which has been monitored for a number of years under the Canada-Alberta Environmentally Sustainable Agriculture Agreement (CAESA), influences the downstream water quality of the Bow River. Starting in

Water quality monitoring along Crowfoot Creek – AAFRD

1996 and continuing for a four-year period, the creek and its tributaries were monitored at 28 different sites. Agricultural inputs of fertilizers and herbicides were found to be high compared to the rest of Alberta. High levels of total nitrogen, total phosphorus, fecal coliform bacteria and three pesticides (dicamba, 2,4-D and MCPA) were also found. Concentrations of atrazine and mecoprop were detected, however, levels were lower leaving the watershed than entering it, indicating the source was upstream of the creek sub-basin and may have originated in upstream urban areas where they are commonly used on lawns and parks.[177 243]

The study results also showed high levels of some trace metals, sodium and dissolved solids, and areas of high soil salinity adjacent to the creek in several places. Fecal coliform counts often exceeded guidelines for irrigation and recreation.

The CAESA report led to the formation of the Crowfoot Creek Watershed Group (CCWG) in 1999, and to the establishment of two beneficial management practice demonstration sites to increase awareness of the problems for area farmers and ranchers. Since then, there have been some practice changes, particularly the use of offsite watering troughs and better protection of riparian areas.[11] A strong push toward the use of no-till and minimum tillage practices that began before the report was published has continued.[204]

In 2000, a research project in the Rosebud River, Serviceberry and Crowfoot creek watersheds identified trends in land use and agriculture with the potential to impact water quantity and quality. Increases in the number of cattle, the increased area on which manure was spread, and the increased use of chemical fertilizers and herbicides were noted as potential risk factors to water quality. However, the additional use of forage crops, surface residues and no-till cropping systems were considered reductions in risks to water quality.[11]

Recently, a new stewardship group, Waters of Wheatland, has been formed to deal with issues for the Rosebud River, Serviceberry Creek and Crowfoot Creek watershed as a whole. The CCWG is also part of this group.

9.6 Where are we Headed?

Reach 7 of the Bow River is included in Phase 2 of the South Saskatchewan River Basin's Water Management Plan (see Chapter 2). Instream flow needs have been determined for several ecological criteria in Reach 7, including water quality, fish habitat, riparian vegetation, and channel structure.[90] After the Water Management Plan is approved, the Government of Alberta will set a Water Conservation Objective (WCO). The WCO will attempt to establish a balance between water consumption and environmental protection of the river, and will determine the maximum amount of water that can be allocated.[24]

Pressure on water resources in Reach 7 is expected to increase in the future. Irrigation demands for water are already high and the number of intensive livestock operations, including beef cattle feedlots, is expected to increase substantially in the future. Future allocations may need to result from conservation efforts and allocation transfers within the basin. With an increase in livestock operations, management strategies for minimizing impacts on water quality and quantity will be especially important.

Increases in industrial water use are also expected in this reach, particularly in Strathmore, as industries locate along the Highway 1 corridor from Calgary to Medicine Hat. As well, oil and gas development is expected to continue. Unless improvements in water conservation, recycling, and oilfield injection programs, are implemented, water use by this industry can also be expected to increase. Recently, the Advisory Committee

Stand Wastewater Treatment Lagoon – AAFRD

WID main canal at Strathmore – C. Lacombe

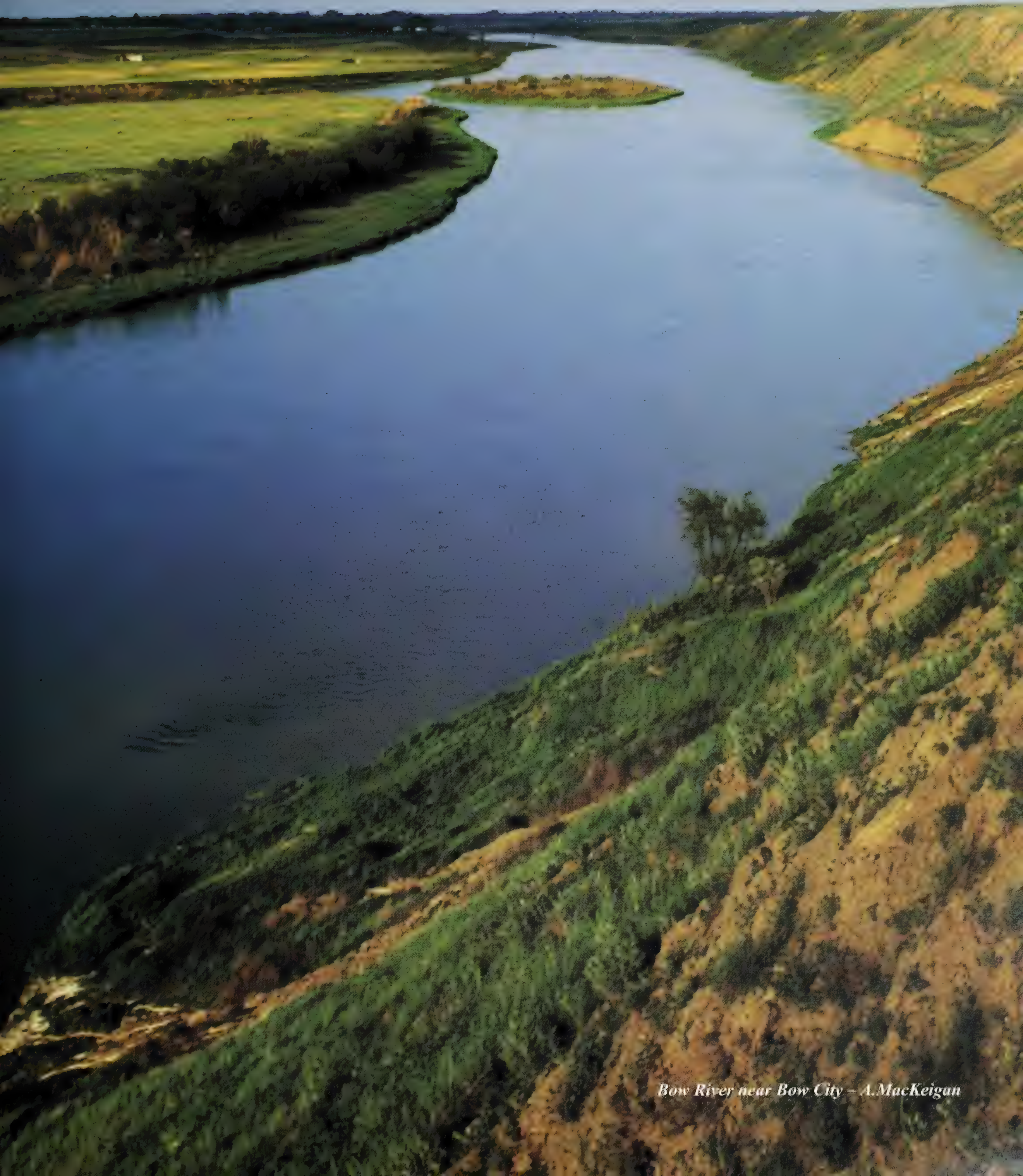
Drop pivot at work – C.Lacombe

on Water Use Practice and Policy recommended that Alberta adopt several initiatives to reduce or eliminate oilfield underground injection of non-saline water as well as broader initiatives for water conservation.[4]

Due to the increasing pressures on water resources within Reach 7, it is important to collect comprehensive information on which to base predictions and make management decisions. There is a hydrometric station downstream of the Carseland Weir that provides water quantity information. Water quality monitoring was conducted at one long-term river network site within this reach, and may be reinstated. Wastewater treatment plants also monitor the quality of water discharged to the Bow River. These monitoring programs provide an excellent database on the status of water quantity and quality along the mainstem of the Bow River in this reach.

Some water quality studies on agricultural impacts have been conducted in Crowfoot Creek. However, long-term information is lacking for non-point sources of pollutants and land use impacts on water quality and quantity, particularly from agricultural production and intensive livestock operations. Though pesticides were regularly monitored at the long-term river network site at Cluny, glyphosate, the most commonly used pesticide in Alberta, was not included in the routine laboratory analysis.[47] While it would entail additional costs, it would be technically possible to add this pesticide to the sampling program. These data gaps represent opportunities to improve the understanding and management of the Bow River within Reach 7.

Chapter 10



Bow River near Bow City – A.MacKeigan

Chapter 10

Reach 8 – Bassano Dam to Confluence with the Oldman River

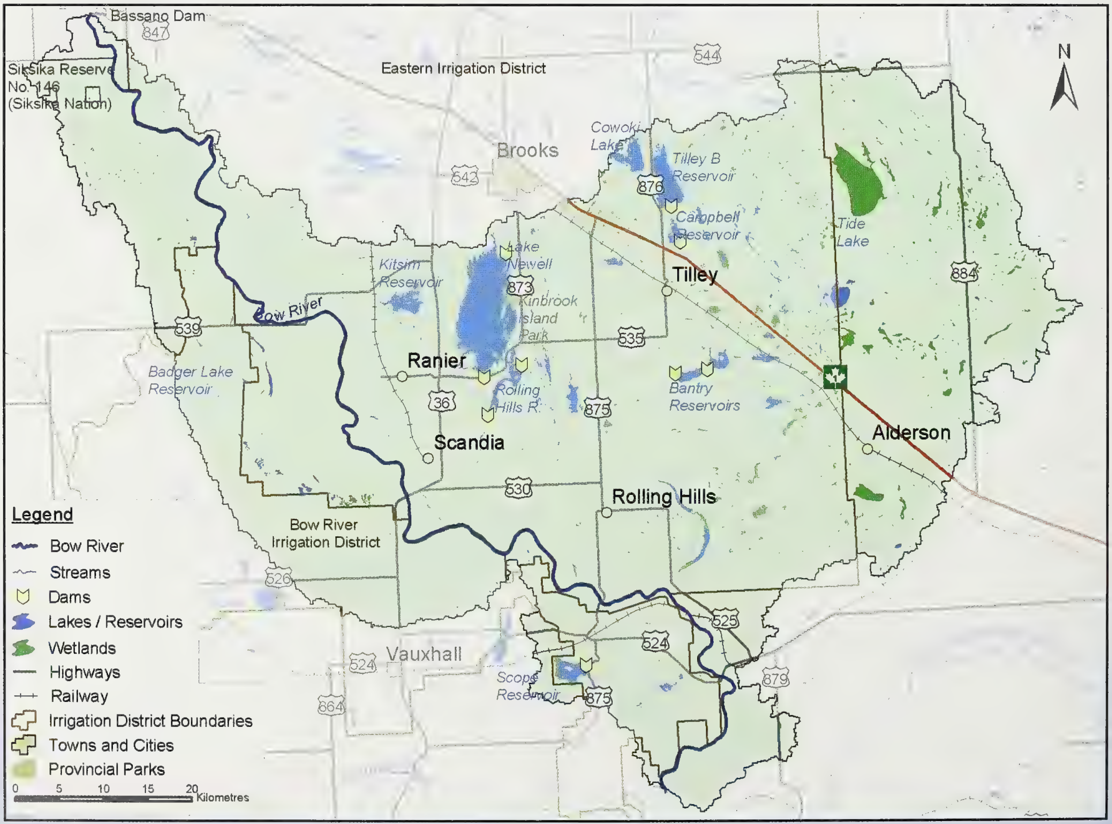
10.1 What is in this Reach?

In Reach 8, the Bow River flows southeast from the Bassano Dam through the prairie to the confluence with the Oldman River, an area called the Grand Forks. The northeast side of the river is located within the County of Newell, while the southwest side of the river is located in the Municipal District of Taber and the County of Vulcan. The total length of Reach 8 is 185 km; it drains an area of 5,357 square kilometres (km^2). There are no major tributaries in this reach; smaller, intermittent tributaries include New West Coulee and Coal and Twelve Mile creeks (Figure 10.1).

The Eastern Irrigation District (EID) covers a large portion of the northeast side of the watershed and the Bow River Irrigation District (BRID) most of the southwest side. Reservoirs in the EID include Lake Newell, Rolling Hills, Kitsim, Tilley B, and Cowoki Lake. At 6,285 ha, Lake Newell is the largest reservoir in the EID system and the largest man-made lake in Alberta. Reservoirs within the BRID include Badger Lake, Lost Lake, H and Scope (Hays).

The landscape is mainly low relief, with some sagebrush flats as well as dune and sand plain complexes. The dry mixed grass prairie is less agriculturally productive, but has a more diverse landscape with higher wildlife populations than other prairie reaches.[228] Wildlife includes grassland species such as white-tailed and mule deer, pronghorn antelope, coyote, white-tailed jackrabbit, and Richardson's ground squirrel. Common birds include the horned lark, sharp-tailed grouse, hawks, and pheasants.

Figure 10.1 Overview map of Reach 8[7 16 39 45]



The upland dune and sand plain complexes are associated with springs and shallow wetlands. These areas support a wide diversity of plants and animals, including several rare plant species and provincially listed wildlife species such as loggerhead shrike, ferruginous hawk, and burrowing owl. Sagebrush flats are another unique habitat type. These areas provide important habitat for lark bunting, Brewer's sparrow, and pronghorn antelope.

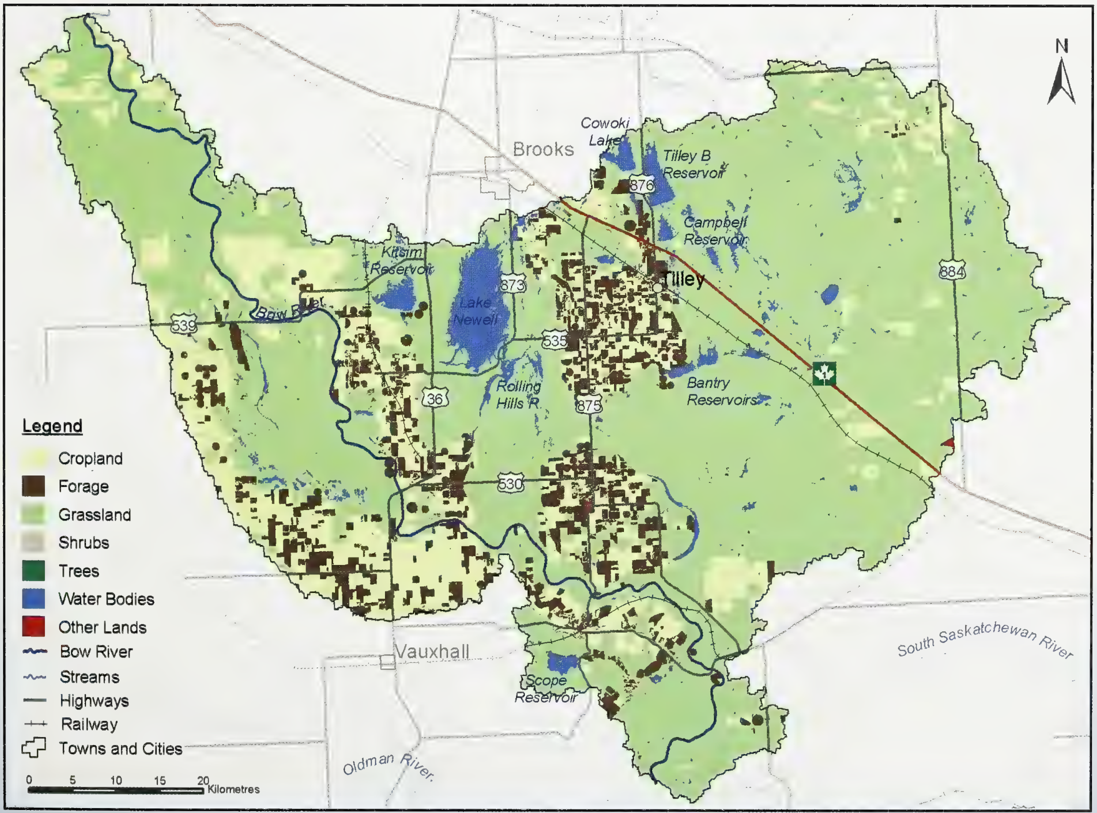
In Reach 8, the river meanders less and the floodplain is narrower and shallower than in upstream prairie reaches. The riparian forest diminishes to scattered clumps of trees and there are exposed rocky outcrops, eroding cutbanks, and cliff faces.[228] This reach provides breeding habitat for geese and staging habitat for dabbling ducks. Water quality is generally good, however, nutrient concentrations are elevated and pesticides are detectable within this reach. In contrast to the cold-water reaches upstream, Reach 8 is cool-water fish habitat and has a substantially different fish community. The most common sportfish species are northern pike and walleye.[197]

The greatest consumptive use of water in this reach is from the Bassano Reservoir at the start of Reach 8. The Bassano Dam is the headworks for the EID, withdrawing water through a series of canals for storage in the EID's offstream reservoirs. The EID also overlaps a large portion of the landbase of Reach 8, therefore both the water withdrawals and land use impacts from the EID are discussed in this chapter.

The BRID withdraws its water from the Carseland Weir in Reach 7; these water withdrawals are discussed in Chapter 9. However, the BRID overlaps a large portion of the landbase of Reach 8, so its land use impacts are discussed in this chapter. See Figure 2.6 for a map of the irrigation districts.

As of 2003, the population in the Reach 8 watershed was about 5,600 people.[36] The population is mainly rural; small communities include Vauxhall, Bow City, Scandia, Ronalane, and Tilley. The Town of Brooks is located in the Red Deer River Basin, just outside the boundary of the Bow River Basin. It is a centre for activity related to land and water use. The population of

Figure 10.2 Land use of Reach 8[6 39 45]



Brooks has grown more than 20% since 1991 (from 9,433 to 11,604), largely the result of increases in agricultural activities, but also due to oil and gas exploration and development.[36 234]

Agricultural activities include dryland and irrigated agricultural crops, livestock operations, feedlots, and meat packing plants. In the County of Newell, more than 80% of the farms use irrigation for crop production and more than 50% of the farms focus primarily on raising beef cattle.[225]

Within the Bow River Basin, Reach 8 (along with Reach 7) has the highest amount of oil and gas development.[117] Historically, oil and gas development has been widespread and this is likely to continue. There are now more than 30,000 oil and gas wells in the County of Newell.[93]

Water withdrawals within Reach 8 are cumulative with those from upstream reaches and substantial changes to the natural flow regime of the Bow River have resulted. The average recorded flows (Figure 10.3) show the modified flow regime that results from upstream hydroelectric dams and water withdrawals, including those of the EID. In Reach 8, the average recorded spring discharge peaks have decreased to around 200 m^3/s. The recorded flows in this reach are lower than those in the rest of the Bow River, with the exception of the headwaters (Reaches 1 and 2). Flows are particularly low during the summer and fall months.

Reach 8 is considered the most highly degraded section of the Bow River Basin.[123]

10.2 Hydrology

The natural flows and seasonal pattern of the Bow River in Reach 8 as illustrated in Figure 10.3 shows the average weekly discharge of the *Bow River below Bassano Dam* (Water Survey of Canada Station AB05BM004) (Figure 10.5). Natural streamflows peak in early June, at an average of 370 cubic metres per second (m^3/s). Natural baseflows in this reach, which consist mainly of groundwater, occur from December through March and average around 30 m^3/s.

Table 10.1 Licensed allocation of the Bow River in Reach 8 (2002)[108 193]

Water User	Annual Licensed Allocation (m^3)	Percentage of Annual Average Bow River Discharge (%)[a]
Industrial	2,911,003	0.07
Irrigation & Agriculture	953,636,543	24.05
Municipal	6,705,981	0.17
Other	1,078,140	0.03
Total	**964,328,667**	**24.32**

[a] Average annual natural discharge of Bow River below Bassano Dam was 3,964,713,166 m^3 (1912 - 2001)

Figure 10.3 Discharge of the Bow River below Bassano Dam (1971 – 2001)[29]

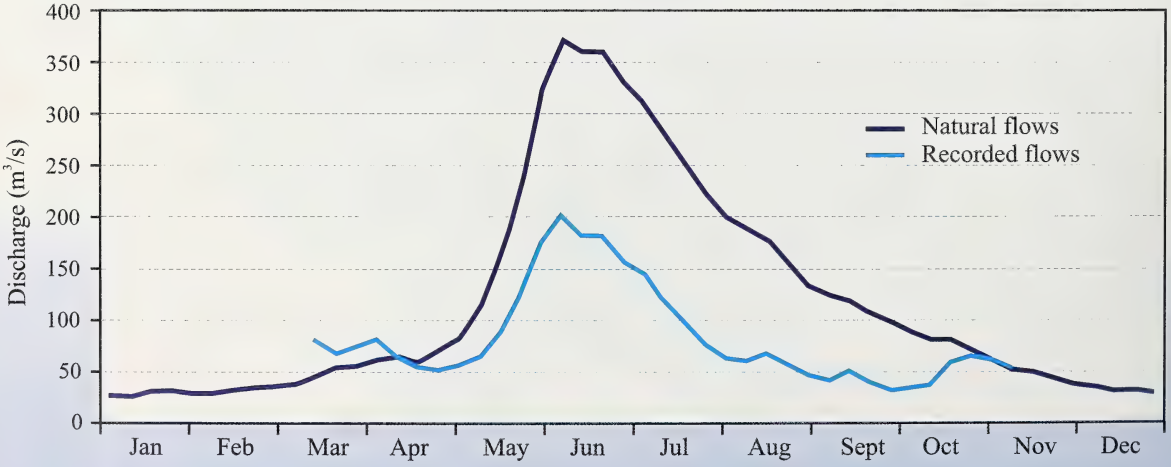


Table 10.2 Licensed and estimated annual consumption and return flows to the Bow River in Reach 8 (2002)[193]

Water User	Annual Consumption from the Bow River (m^3)		Annual Return Flows to the Bow River (m^3)	
	Licensed	Estimated[a]	Licensed	Estimated
Industrial	2,911,003	623,700	0	0
Irrigation & Agriculture	808,085,686	412,305,879	145,550,857	119,647,738
Municipal	2,732,412	1,268,890	3,970,569	3,620,882
Other	1,078,140	319,550	0	0
Total	**814,807,241**	**414,518,019**	**149,521,426**	**123,268,620**

[a] When water use reports for each license are absent, the licensed consumption and licensed return flows are used to approximate the estimated consumption and return flows, respectively. This likely overestimates the estimated consumption and return flow data in this reach

How do Water Withdrawals Affect Hydrology?

Table 10.1 outlines the water licence allocations for the Bow River in Reach 8 for 2002, as provided by Alberta Environment. The total volume of water licensed for diversion by all users was more than 964 million cubic metres (m^3) in 2002. These extractions represent about 24% of the long-term average flow for the *Bow River below the Bassano Dam*. More than 98% of the total allocation within Reach 8 is for irrigation and agricultural purposes.

In 2002, the annual licensed allocation (that is, consumptive uses plus water losses and return flows) for irrigation and agriculture was about 803 million m^3. The EID is the largest water user in Reach 8. Their water is withdrawn at the Bassano Dam and transferred through a series of canals and reservoirs. There are also more than 30 smaller agricultural and private irrigation licensees who use their water allocations for stockwatering, feedlot operations, and irrigating crops. The BRID withdraws its water in Reach 7, as discussed in the previous chapter, but it returns about 30% of its licensed consumption to the Bow River in Reach 8.

Actual consumption of water for irrigation and agriculture varies greatly from year to year, depending on the weather (Table 10.2). In 2002, estimated irrigation and agricultural consumption for Reach 8 was 408 million m^3 or about 51% of licensed consumption. Estimated return flows were 119 million m^3 for the year.

In 2002, less than 2% of licensed water withdrawals were for uses other than irrigation and agriculture. Industrial uses included oilfield injection, packing plants, food processing, aggregate washing, and market gardens. No return flows were associated with industrial users.

Bassano Dam

The communities of Bassano, Brooks, Tilley, Duchess, and Rosemary, the County of Newell, and three Hutterite colonies all draw water from the canals or reservoirs of the EID, though they have separate municipal licences and their water use is calculated separately from the EID allocation (Table 10.2). Some of the water allocated for municipal diversions in 2002 was returned to the Bow River, via the EID channels, in the form of treated effluent discharges. Return flows from Bassano, Brooks and Duchess are transferred to the Red Deer River basin via the EID infrastructure.[137]

As described in Chapter 9, Vauxhall, Lomond, Milo, and the Municipal District of Taber draw water from the BRID, which diverts water from the Carseland Weir at the upstream end of Reach 7. Hence, municipal water licences for these communities are accounted for and discussed in Reach 7 water allocations.

The "other" Reach 8 water licenses include golf courses and recreation areas. Water use by these facilities is consumptive, with no water being returned to the Bow River in 2002.

How does Land Use Affect Hydrology?

Approximately 1,256 km^2 (about 24%) of the landbase is used for forage and crop production, mostly irrigated crops within the EID and BRID. The two irrigation districts cover a large portion of the landbase, with more than 191,000 ha of the land assessed for irrigation. The primary irrigated crops grown are forages and cereals, with smaller amounts of oil seeds and specialty crops.[246] More than 42,000 ha of irrigated alfalfa (for hay and silage) and almost 29,000 ha of irrigated wheat varieties were produced in the EID and BRID in 2003. Wheat is also grown as a dryland crop.

Specialty crops include beans and peas, sugar beets, potatoes, and alfalfa for seed.[9] Farm diversification has been fostered by the Crop Development Centre South at Brooks (formerly the Provincial Horticultural Station). A processing plant for the fresh potato market and a potato starch plant are located in the BRID near Vauxhall and there are several large seed processing plants in the area.

The Eastern Irrigation District Conveyance System

The EID conveyance system consists of a series of canals, pipelines and reservoirs. Approximately 33% of the more than 2,048 km EID distribution system is buried pipeline, installed to reduce evaporative and operational spill losses. Water for the EID system is withdrawn from the Bow River at the Bassano Dam, at the west end of Reach 8, then flows via a district-owned headworks canal to the Little Dam. This structure, essentially a diversion weir, impounds the water in the coulee behind it, just enough so flows can be divided into two branch canals. The North Branch Canal flows into the Crawling Valley Reservoir. A canal out of this reservoir services farmland around the community of Gem and eventually drains into the Red Deer River.

The East Branch Canal flows southeast and splits into two subsequent canals. The more northern canal flows into Rock Lake Reservoir and services areas around Duchess, Millicent, Patricia and Rosemary, eventually draining to the Red Deer River. The southern canal flows into a series of reservoirs west and south of Brooks, including Snake Lake, Kitsim, Lake Newell, and Rolling Hills. These reservoirs provide water to farmers in the Brooks, Rainier, Scandia, Tilley, and Rolling Hills area. Canals also link to a series of reservoirs east of Brooks, including the One Tree, Cowoki, Tilley B, Campbell, Bantry #1, and Bantry #2. These lands drain to the Bow River. While some of these lands drain into the lowest reach of the Bow River, much of the EID is located within the Red Deer River Basin and approximately half the flows drain into the Red Deer River. However, both the Red Deer and the Bow River converge downstream in the South Saskatchewan River Basin.[194]

Irrigation pipeline installation in the EID – AAFRD

The move to diversification, while beneficial in terms of crop rotations and the farmers' bottom line, can increase the amount of water needed. Crops such as potatoes, sugar beets and alfalfa need more water than cereals and most forages.

The forage crop production, part of the cereal crop, and the reliable supply of water from the Irrigation Districts are used to support a large livestock industry, including a major meat packing plant at Brooks. The estimated livestock population within Reaches 7 and 8 is higher than in other Bow River reaches.[137] In addition to about 250,000 cattle raised in the Counties of Newell and Vulcan, the region is a net importer of feeder cattle, finished at local feedlots.[116] Water use for livestock operations is expected to increase substantially in the future (see Chapter 2).[137]

About 3,743 km^2 (72%) of the landbase is classified as grasslands, much of which is used for grazing. The EID owns and operates more than 240,000 ha of native grassland that is leased to 10 community grazing associations for 45,000 cattle.[194] There is no site-specific data on the impacts of these land-use practices on the water quantity of the Bow River or its sub-basins (see Chapter 2).

Agricultural development has also led to the drainage and conversion of wetlands (see Chapter 2), but wetland habitat has also been created, as part of the irrigation infrastructure, as well as in specific wetland restoration and construction projects. The grazing area, developed by the EID and partner organizations, supports about 16,000 ha of wetland habitat for prairie plants and wildlife. Although there is no site-specific information on how changes in the area and type of wetlands have affected water quantity in Reach 8, it is important to note that without the diversion of water from the Bow River for irrigation, there would be no reliable water supply other than the river itself for industry, residential development, and recreation within the reach.[12,244]

Drop tube centre pivot sprinkler in potato field - AAFRD

10.3 Water Quality

During the past 20 years, Calgary has performed numerous upgrades to its wastewater treatment capacity and has greatly reduced suspended solids, organic material, bacteria, and nutrient loading to the Bow River.[117 249] However, the most significant point source influences on water quality in this reach remain the City of Calgary's Bonnybrook and Fish Creek wastewater treatment plants (WWTPs).[249] There are no direct municipal point source discharges into the Bow River in Reach 8. Bassano treats its wastewater in a lagoon and discharges it into a wetland for tertiary treatment.[117] Brooks discharges treated wastewater into One Tree Creek, a tributary of the Red Deer River; Tilley discharges its treated effluent into an EID irrigation canal. Return flows from the EID and BRID are discharged into the Bow River through several spillways and outlet canals along Reach 8.[249]

Alberta's irrigation canals can be sources of nutrients (phosphorus and nitrogen) and bacteria in surface waters, and return flows often contain higher concentrations than source waters. Pesticide concentrations have also been found to be higher in irrigation canals than in other surface waters. Pesticide levels in canals generally increase farther downstream, with maximum levels found at return flow locations, where the water is returned to the river.[65] The EID regularly monitors the water quality at the EID intake as well as throughout the canals and return flows.[194]

Other influences on the water quality of the Bow River in this reach include wastewater effluent and surface water runoff from agricultural cropland, feedlots, and pasture. Feedlot manure accumulates in large quantities, and may be applied to fields more heavily than the land and vegetation cover can assimilate. As such, excess nutrients can run off into surface waters or leach into groundwater.

Pesticide concentrations in surface waters have been found to be directly correlated to the amount of pesticide applied locally. Elevated herbicide concentrations have been found during spring runoff, indicating that some herbicides persist in the soil over the winter.[65] However, these non-point source influences are difficult to quantify and little specific information exists regarding their impact on the water quality of Reach 8.

Water quality in irrigation canals

Both agricultural runoff and municipal wastewaters can be sources of pollutants in irrigation canals. Elevated nutrient concentrations in irrigation canals can stimulate the production of aquatic plants, which can impede water flows and clog structures and screens. Irrigation districts need to remove these aquatic plants to ensure efficient operation of the canals and the on-farm irrigation equipment they support. Decaying plant material can also consume oxygen in the water, with the potential to stress aquatic organisms in both the canals and associated reservoirs. Occasionally high bacterial concentrations may pose risks to recreational users, who swim in the canals during the summer. Canal water quality is also a concern for the many small communities that rely on the irrigation districts for their municipal water supply. Any deterioration in the quality of their water source may require additional treatment and cost by the communities to ensure the safety of the water supply.

Control structure on BRID canal – AAFRD

Water quality of the Bow River at Ronalane Bridge

Water quality in Reach 8 of the Bow River is measured at *Bow River at Ronalane Bridge* (AENV LTRN Site 00AL05BN0001), about 154 km downstream from the west end of the reach. The site is located where Hwy 524 crosses the Bow River, northeast of the community of Hays (Figure 10.5). This site is part of Alberta Environment's long-term river network (LTRN) monitoring program. Recent water quality assessments include the determination of Water Quality Indices (WQI) for several suites of key variables, including metals, nutrients, bacteria, and pesticides. An overall average WQI has also been generated, based on the results of the suites of variables.[27]

The WQI has been calculated at this site for the past decade, spanning 1990 to 2001 (Figure 10.4). During this period, the average WQI has been rated as good for most years, with the exception of 1998/1999 when it declined to fair, the result of marginal pesticide ratings.

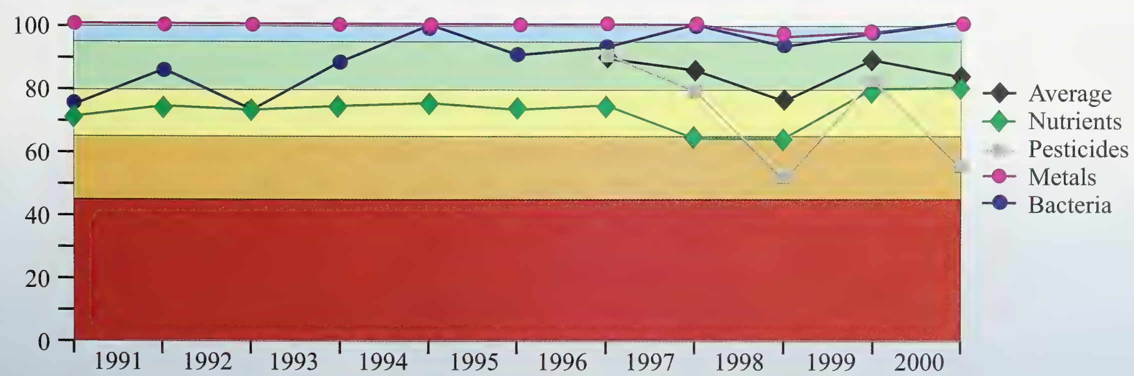
Nutrients consistently rated fair throughout the early period of record, from 1990/1991 to 1996/1997. The next two years, the nutrients rating declined to marginal. In 1999/2000, ratings improved to fair and finally, to good in 2000/2001. Both nitrogen and phosphorus were found to exceed guidelines for the protection of aquatic life during the sampling period. Total nitrogen regularly exceeded the water quality guideline, but like the Bow City site, these exceedences were found only during the winter months. During the summer months, uptake by aquatic plants may play a role in lowering the total nitrogen concentrations in the water. Total phosphorus also regularly exceeded the water quality guideline, but generally only during the spring and summer.

The elevated total phosphorus concentrations during the spring could be associated with sediments in spring snowmelt and surface runoff. An explanation for the summer increases in total phosphorus at this site is not evident. While improvements in nutrient ratings were noted in the last few years, the historic nutrient ratings at this station point to long-term nutrient enrichment from point sources such as the Calgary WWTPs.[249]

In winter, the Sauki Spillway also contributes to phosphorus concentrations. It is likely that the addition of these nutrients have increased the productivity of the system and altered the aquatic community within this reach. Like other sites along the Bow River, the improved nutrient ratings over the last few years of record may be due to improvements in nutrient removal at Calgary's WWTPs.

Pesticides were not rated until 1996/1997. Once they were included in the program, pesticide ratings were highly variable, ranging from good to fair to marginal over the period of record. While most samples were below the detection limits, some detections of atrazine, bromoxynil, diazinon, dicamba, dichlorprop, lindane, MCPA, MCPP, and 2,4-D were found. 2,4-D, MCPP and MCPA were the most commonly detected pesticides. 2,4-D is used to control broadleaved weeds on agricultural, pasture and urban lands, while MCPP is more commonly used for cosmetic lawn purposes. MCPA is used to control broadleaved weeds in cereals and grassland. Atrazine, bromoxynil, dicamba, and MCPA were also found to occasionally exceed water quality guidelines for irrigation, livestock watering and the protection of aquatic life.

Figure 10.4 Canadian water quality index for the Bow River at Ronalane Bridge[27]



Of all sites along the Bow River, the Bow River at Ronalane had the poorest pesticide ratings. These results highlight the need for continued pesticide monitoring. Improvements in pesticide application timing and application rates may also be required in order to reduce levels in the Bow River. The results have been influenced by the focus on spring and summer sampling in the later years, compared to year round sampling in the earlier years. Additional years of data are required to determine if concentrations of pesticides are increasing at this site.

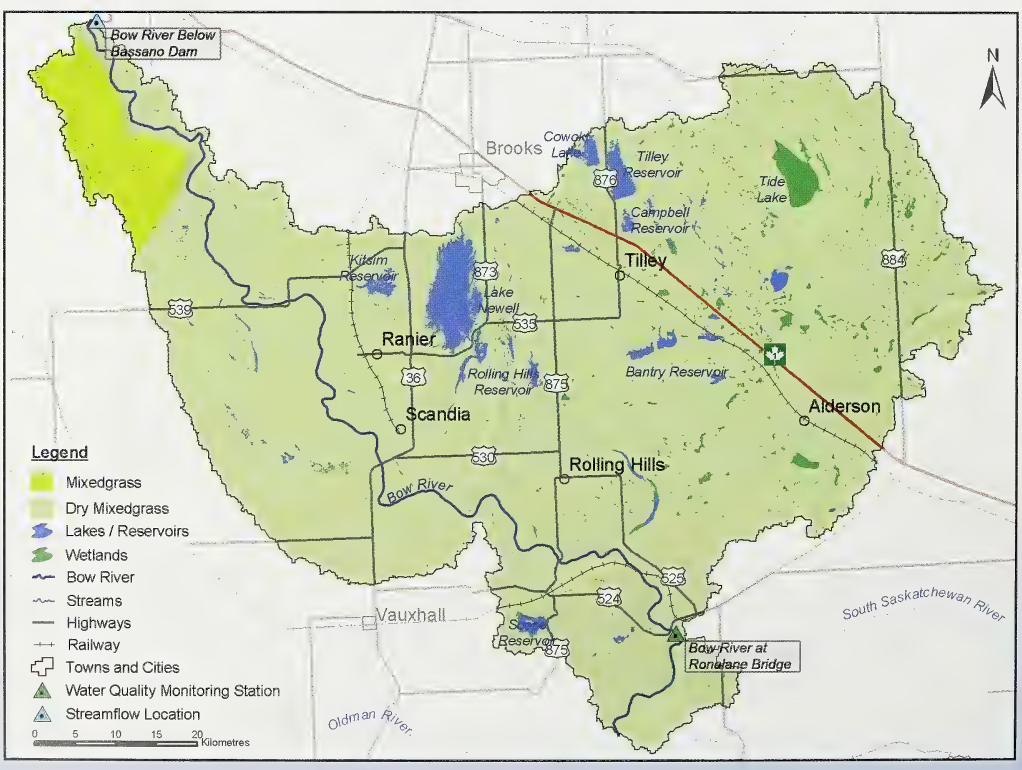
Bacterial concentrations within Reach 8 rated fair to good in the early 1990s and improved to good to excellent by the end of the sampling record. Bacteria levels remained excellent from 1999/2000 to 2000/2001. Lower ratings during the early 1990s were due to occasional exceedences of the guideline for irrigation use by fecal coliforms and E. coli. Fecal coliform counts exceeded the recreational guideline once during the 10 years of sampling, with no risks for recreational users, although higher bacterial counts were found during the summer, the time of greatest recreation and irrigation use of the river. No risks to recreation or agriculture users were found in the 2000/2001 sampling year.

Major point sources of fecal coliforms and E. coli include the Bonnybrook and Fish Creek WWTPs.[249] The improved bacterial ratings throughout the 1990s are likely due to improvements in disinfection and wastewater treatment by municipalities discharging into the Bow River. Bacterial loadings from non-point sources such as agricultural runoff are not easily quantified, but likely contribute to concentrations in the river.[203] Drain D (an irrigation drain located north of Vauxhall) contributed a small portion of the fecal coliform loading in the lower portion of Reach 8.[249]

Intensive feedlot operations have also been implicated as sources of bacteria and pathogens in surface waters. Grazing practices that allow the animals and their wastes to enter the river directly also increase the presence of bacteria and other pathogens.[65]

Ratings of metals were consistently excellent over the sampling period. During the 10 years of sampling, only two samples were found to exceed water quality guidelines, indicating no concerns for long-term water quality or the health of aquatic organisms. The sources of these metals include wastewater effluent from Calgary and natural tributary sources.[249]

Figure 10.5 Natural sub-regions and measuring locations of Reach 8[23 39 40 45 195]



10.4 Ecosystems

Terrestrial Habitat

The watershed of Reach 8 is located within the grasslands natural region, with most of the landbase in the dry mixed grass sub-region (Table 10.3 and Figure 10.5).[19] A small area along the Bow River is within the mixed grass sub-region. Both sub-regions have low relief. Sandy areas are more common in the dry mixed grass sub-region.

The vegetation and wildlife characteristic of the mixed grass sub-region are described in Chapter 9. Due to its drier and hotter climate, the dry mixed grass region has a lower biomass production, but has the highest plant diversity of all the grassland sub-regions.[19]

Vegetation in the dry mixed grass sub-region is characterized by short and mid-height grasses. Common mid-height grasses include spear grass, western wheat grass, and June grass; blue grama is the most common short grass. Northern wheat grass and western porcupine grass are present on more moist sites. Spear grass, sand grass, and June grass are common in sand dune areas, as are shrubs such as sagebrush, silverberry, western snowberry, and prickly rose. Agricultural crops (about 24% of the landbase) have replaced some natural vegetation, impacting not only the plant communities, but also the wildlife they support, thus decreasing biodiversity.

Grazing has also influenced native grassland areas. Birds such as the horned lark, McCown's longspur, and chestnut-collared longspur are common in heavily grazed areas; Baird's sparrow, Sprague's pipit, sharp-tailed grouse, and upland sandpiper occur in lightly grazed areas that are more representative of native grasslands.[19] White-tailed jackrabbit tolerate a range of grazing conditions and occur throughout the landbase, while Richardson's ground squirrel is common in heavily grazed areas.

Table 10.3 Size and extent of Reach 8 features[23,39,40,45,195]

Feature	Area (km^2)	Extent of Area (%)
Mixed grass sub-region	212.0	4.05
Dry mixed grass sub-region	4,749.6	90.79
Lakes	22.4	0.43
Reservoirs	122.9	2.35
Lagoons	0.1	< 0.01
Wetlands	96.9	1.85
Rivers	26.5	0.51
Canals	1.0	0.02
Total	**5,231.4**	**100.00**

Sagebrush flats are a unique habitat type within the grassland natural region and provide important habitat for the lark bunting, Brewer's sparrow and pronghorn antelope. Sand plains and dune areas occur within the dry mixed grass prairie. Several, including the Little Rolling Hills, Lower Bow Dunes, and Wolf Island Dunes, have been identified as environmentally sensitive areas based on their unique habitat features and the diversity of plants and wildlife they support.[228] Each of these areas is unique, but share similar features such as sand dunes, springs and shallow wetlands.

Little Rolling Hills, located at the south end of Lake Newell, is a hill system with sand plains and dunes that hosts many rare plants, including obscure evening primrose and blue toadflax. Springs and wetlands, including several saline wetlands, are associated with the hills. Breeding populations of plains spadefoot and Great Plains toad occur, both of which are classified as "may be at risk" in Alberta (see Chapter 2).[44] The Little Rolling Hills also provides nesting areas for loggerhead shrikes and ferruginous hawks, as well as sharp-tailed grouse dancing grounds. This hill system is also important pronghorn antelope and deer habitat.


Antelope – A.MacKeigan


Coyote


Richardson's ground squirrel

The Lower Bow Dunes are located just north of the confluence of the Bow and Oldman rivers. These sand dunes have active sand blowouts, which are important habitat for several rare plant species, such as low-milk vetch, low annual lupine, and sand verbena. The dunes also provide habitat for pronghorn antelope, grasshopper sparrows, and lark buntings, as well as feeding areas for birds of prey that nest along the Bow and Oldman Rivers.

The Wolf Island Dunes also have active sand blowout areas and contain rare plant species, notably low annual lupine, sand verbena and bur-sage. Burrowing owls, considered "at risk" provincially,[44] nest here and the dunes are also breeding habitat for grasshopper sparrows and Brewer's sparrows.

Exposed outcrops and cliffs along the Bow River are important nesting habitat for birds of prey such as prairie falcons, golden eagles and ferruginous hawks.

Pheasants Forever and the Partners in Habitat Development Program

Pheasants Forever Calgary is a conservation organization whose purpose is to protect and enhance pheasant, grouse and other upland bird and wildlife populations.[illegible] Pheasants were introduced from Eurasia in 1908 and have become naturalized in southern Alberta. They provide important hunting opportunities. Pheasants Forever focuses on habitat restoration and enhancement. Two key initiatives include water quality preservation projects and the Partners in Habitat Development Program. Water quality preservation projects are done in partnership with watershed groups and focus on improving surface water quality in farmland streams.

Pheasants Forever Calgary and the EID initiated the Partners in Habitat Development (PHD) Program,[illegible] a partnership between southern Alberta irrigation districts, industry, government, conservation organizations, and landowners.[illegible] Its aim is to maintain and enhance wildlife habitat within the irrigation districts in southern Alberta. It now operates in all three of the Irrigation Districts within the Bow River Basin. PHD projects are done in cooperation with landowners who allocate portions of their land for habitat conservation and enhancement. The projects are designed to benefit both landowners and wildlife, and may include the following:

- Planting vegetation along irrigation right-of-ways, irrigation pivot corners and unused farmland to provide nesting cover for ground nesting birds
- Creating vegetation buffers along streams to provide cover and corridors for wildlife as well as to improve water quality
- Developing shelterbelts, which function to provide wildlife habitat, connect key habitat areas, shelter livestock and conserve soil
- Fencing newly planted areas to control livestock grazing
- Preserving cattail marshes
- Establishing winter food plots

Ring Necked Pheasant – A. Mackeigan

Three full-time habitat technicians, a host of volunteers, donations of trees and shrubs from the Prairie Farm Rehabilitation Program (PFRA), and more than $1,000,000 in funding from member organizations and other fundraising efforts had been invested in PHD projects as of 2004, with resulting habitat improvements on more than 6,070 ha of upland wildlife habitat.

Richardson ground squirrels are abundant in the upland areas associated with the Louisiana Lakes and provide an important food source for American badgers and long-tailed weasels ("may be at risk"). These lakes are a Ducks Unlimited project, and receive water from the Tilley B Reservoir. Unique flat terrain provides nesting areas for ferruginous hawks and feeding areas for prairie falcons and golden eagles. Key mule deer habitat is found in coulees and spring areas and pronghorn antelope habitat is found near the confluence with the Oldman River. Springs in the area provide habitat for northern leopard frogs ("at risk").[44 228]

Riparian and Wetland Habitat

Reach 8 of the Bow River has fewer meanders than the upstream reaches, with a narrower floodplain that ranges from 200 to 500 m wide.[90] The river valley is shallow, with small coulees and grassy terraces, exposed rocky outcrops, and eroding cut banks.[228] In some areas, springs are present. Within this reach, the riparian poplar forest is sparse, diminishing to scattered clumps of trees.[90 197] Human activity within the floodplain is minimal and includes agricultural uses such as grazing. The reduced flows in this reach greatly impact the floodplain and its function is considered degraded.[123]

Plains cottonwood is the most common cottonwood species in the riparian areas of Reach 8; balsam poplar is also present. Riparian forests are dependent on flooding for the recruitment of new saplings; the magnitude of the floods as well as their timing and pattern are important.[201] Since the 1930s, however, poplar recruitment has been low, with only a few minor recruitment events. In addition to changes to the natural streamflows, drier climatic conditions may also have led to low recruitment.[201] Although some cottonwood regeneration occurs vegetatively, seedlings are needed to maintain genetic diversity and replenish the forest density. While the riparian forest density is currently similar to what it was in the late 1800s, it is estimated that if significant recruitment does not occur, the riparian forests could be gone in the next 100 to 150 years.[92] Overall, the cottonwoods are considered seriously degraded.[12]

Riparian health was assessed by the Cows and Fish Program, which found this reach to be unhealthy.[38] Disturbance-caused plant species covered over half the area assessed; invasive plant species were sparse but widely distributed. Common invasive plant species in Reach 8 include Canada thistle, scentless camomile, and perennial sow thistle. Native grass cover was variable, ranging from good to very poor. Shrubs covered about half the area assessed; however, use of shrubs for grazing was moderate to heavy.

Riparian wetland habitat along the Bow River is limited due to its steep banks. However, as in Reaches 6 and 7, this reach provides important breeding habitat and nesting sites for geese. The water in this reach is

Snow geese on Scope Reservoir – R.Phillips

too shallow to provide protection from predators and feeding habitat for diving ducks,[51] but it does provide important staging habitat for dabbling ducks in spring and fall.[228]

Though wetlands have been drained for agricultural cultivation, many wetlands still remain, and others have been created in association with native grasslands. Many previously drained agricultural lands have been converted back to wetland use or provide permanent native vegetation. As well, wetland habitat has been created, both intentionally and unintentionally, within irrigation canals and reservoirs. The development of irrigation, especially the creation of the EID, has resulted in more wetland habitat than in the pre-settlement landscape. The irrigation canals provide linear habitat that also serves as wildlife movement corridors and is easily searched by predators. As a result, waterfowl nesting may be abundant in these canals, but their success is poor. Since the early 1940s, Ducks Unlimited Canada (DUC) has been working with the irrigation districts and today there are more than 16,000 ha of managed wetlands in the EID that provide critical habitat. There are 12,000 ha of wetlands within the BRID.[57]

Several of the wetlands and irrigation reservoirs are considered environmentally significant. Lake Newell is nationally significant; its islands provide important nesting habitat for the ring-billed gull, non-breeding American white pelican, and double-crested cormorant. It also provides staging areas for geese and shorebirds, and breeding ponds for the Great Plains toad. Rare plant species such as slender mouse-ear cress and water hyssop are also found at Lake Newell.[228]

The Scope (Hays) Reservoir is provincially significant for its double-crested cormorant and American white pelican colonies. It also provides breeding habitat for the Great Plains toad. The wetland areas around the Lower Bow Dunes provide important breeding habitats for the Great Plains toad, as well as breeding and staging areas for ducks. The wetlands associated with the Louisiana Lakes are provincially significant. They are important staging areas for geese and ducks and also host double-crested cormorant and gull colonies.[228]

The Bow River Irrigation District and Ducks Unlimited Canada Agreement

In 1985, the Bow River Irrigation District (BRID) and Ducks Unlimited Canada (DUC) initiated an agreement to integrate wetland management. This agreement has resulted in the restoration of 140 wetlands, including 550 km of shoreline and 2,300 ha of wetland habitat. These projects have helped educate irrigation farmers that they can coexist with waterfowl and that proper wetland management can be beneficial to both.

This broad long-term agreement to enhance and conserve habitat heralded the first commitment to wildlife habitat and management by an irrigation district. The construction of the Badger Lake Reservoir in 1983 and the Lost Lake Water Reuse project in 1985 have dramatically increased the BRID's efficiency of operations. They ensure that additional water availability will alleviate potential shortages and allow more irrigated acres. At the same time, the agreement ensures the continuation of wetland habitat within the BRID.

The DUC Medicine Wheel Landscape is one of many projects within this agreement. The area north of the Badger Lake Reservoir is fed with water from the BRID, with surplus flows returning to Reach 8 of the Bow River. In addition to 384 ha of wetlands, the landscape encompasses 19,140 ha of uplands, the majority of which remain in native prairie. A comprehensive management plan ensures the preservation and health of the grasslands. Using a rotational grazing system, tame pastures are used during the spring to defer the grazing of the native grasslands, particularly around the wetland riparian zones. Together with another grazing scheme located south at the Circle E intensive management unit, 39,064 ha of grassland, dotted with thriving wetland habitats, have been preserved in a single immense prairie landscape. This project is representative of all DUC's major conservation programs, with aspects of wetland and upland restoration, as well as cooperation between conservation groups, government, and the agricultural industry.

Aquatic Habitat

Downstream of the Bassano Dam, the Bow River is cool-water aquatic habitat, suitable for fish species that can tolerate the warmer, slower and more turbid water found in this reach. The most abundant sportfish are northern pike and walleye. Lake sturgeon are found in the lower part of the reach, primarily within a few kilometres of the mouth.[197] Cold-water fish species (rainbow and brown trout and mountain whitefish) are rare in this reach and decline in number downstream.

Irrigation withdrawals greatly reduce the spring, summer and fall flows of the river downstream of the Bassano Dam, restricting fish habitat. With lower flows, the temperature of the water is able to rise more quickly during the summer, and temperatures can exceed the tolerance of even the cool-water fish species. During times of low flows, the warm, shallow, nutrient-rich waters can occasionally experience low dissolved oxygen concentrations, pH fluctuations and high ammonia concentrations.[90] Although water quality has improved greatly since the fish kills seen throughout the 1960s to 1980s, the periodic occurrence of these conditions can still stress the fish in the river.

The presence of dams and water control structures influences the movement of fish within the Bow River system. The Bassano Dam at the top end of Reach 8 is generally considered to be a physical barrier to upstream fish movements.

The BRID and EID reservoirs support fish populations and have recreational fisheries for northern pike and lake whitefish.[197] Lake Newell has also been stocked with walleye. People catching fish in Reach 8 of the Bow River should be aware of the fish consumption advisories set by Health Canada. Women of child-bearing age and children under 15 are advised not to eat northern pike and walleye caught in the Bow River downstream of the Bassano Dam. All other people are advised to eat these species no more than once a week. These advisories have been set due to risks from the possible presence of mercury, which can accumulate in fish tissues, especially larger predatory fish. In Alberta, most mercury accumulations in fish appear to come from natural soil sources.[42]

Bow River near mouth – R.Wolfe

10.5 Where are we Headed?

Reach 8 of the Bow River was included as one of the high priority reaches in Phase 2 of the South Saskatchewan River Basin's Water Management Plan (see Chapter 2). Instream flow needs have been identified for several ecological criteria in Reach 8, including water quality, fish habitat, riparian vegetation, and channel structure.[90] Ultimately, the Government of Alberta will set a water conservation objective for this reach. The Water Conservation Objective will attempt to establish a balance between water consumption and environmental protection of the river.[24] Currently, however, there are insufficient flows to meet all these demands, resulting in the degradation of aquatic and riparian habitats. The maximum amount of water that can be allocated has already been licensed.[176]

Pressure on water resources in Reach 8 is expected to increase in the future. Irrigation demands for water are already high and have recently been increased. The Irrigation Districts have responded by becoming more efficient. In 2004, the EID completed an expansion of the Rolling Hills Reservoir to create more off-stream storage. Two major dams and six dikes were added and the reservoir was raised. The project will help stabilize water flows to irrigators without adding to the amount of water actually used. Water allocation transfers may also help conserve water resources and allow further improvements in the efficiency of the systems (see Chapter 2).

Water use for intensive livestock operations is also expected to increase within the landbase of Reach 8.[137] With an increase in livestock operations, management strategies for minimizing their influence on water quality and quantity will be important.

Increases in industrial water use are expected as industries locate along the Highway 1 corridor from Calgary to Medicine Hat.[137] Oil and gas development is expected to continue. Unless improvements in water conservation and recycling, including oilfield injection, are implemented, water use by this industry can also be expected to increase. Recently, the Advisory Committee on Water Use Practice and Policy recommended that Alberta adopt several initiatives to reduce or eliminate oilfield injection of non-saline water as well as broader initiatives for water conservation.[4] If these initiatives are implemented, water use by oil and gas could be reduced.

Two electrical power projects are being considered. The EID has considered a power generation facility at the Bassano Dam; this project is currently on hold. If implemented, the project would have no impact on the flows of the Bow River.[255] A coal-fired power generation plant, proposed for the area near the Kitsim Reservoir, may have more impact. Municipal water use is expected to increase as populations grow, however, per capita consumption of water is expected to decrease as municipalities adopt water conservation and efficiency measures.[137]

Due to the increasing pressures on water resources within Reach 8, it is important to collect comprehensive information on which to base predictions and make management decisions. A hydrometric monitoring station measures water quantity, while water quality monitoring is conducted at one site. These monitoring programs provide an excellent basis of information on the status of water quantity and quality along the mainstem of the Bow River in this reach.

Information is lacking on non-point sources of pollutants and land use impacts on water quality and quantity, particularly from agricultural production and intensive livestock operations. These data gaps represent opportunities to improve the understanding and management of the Bow River within Reach 8.

Chapter 11

Tundra Swan – A.MacKeigan

Chapter 11

What is Being Done?

11.1 Stewardship

There are many stewardship organizations, government bodies, community groups, academic institutions, and industries that operate within the Bow River Basin and share a common goal: to improve the management and protection of water resources in the Bow River Basin. These groups perform a wide variety of functions, from research, monitoring, enforcement, and restoration to education, planning and policy development and implementation. Through their programs, current management practices may be improved to mitigate or potentially avoid further pressures on the basin's limited water resources.

Since the last State of the Bow River Report was written in 1994, there has been substantial media attention and public interest in the basin's water resources. Organizations continue to form within the basin, each with their own focus, challenges and success stories. The following paragraphs describe some of the programs and organizations currently active across the basin. Other programs that operate within certain reaches have been highlighted in the individual reach chapters. It was not possible to acknowledge all programs and groups worthy of attention in this report. If your organization has not been mentioned and you would like your activities to be included in the next State of the Bow River Basin Report, please contact the Bow River Basin Council at (403) 254-3419 to share your information.

The Bow River Basin Council (BRBC)

The BRBC represents a group of organizations and individuals who share a common belief that the water resources within the Basin represent our lifeline and are to be conserved and protected. The broad mission of the BRBC is to encourage cooperative and effective strategies for water use management and environmental stewardship. Representatives on the Council include urban and rural municipalities, the irrigation industry and cooperative districts, commercial and industrial companies, educational, recreational and ecological interests, First Nation peoples, the provincial and federal governments, and highly committed members of the general public. In 2004, the Government of Alberta formally recognized the BRBC as the Watershed Planning and Advisory Council for the Bow River Basin.

The Council's ultimate goal is to participate in or promote activities that will help the Bow River Basin achieve the best water quality of any highly populated river basin in Canada. The Council seeks to work with partners in establishing the Bow River Basin as the best managed watershed in the world. To learn more about the BRBC or if you wish to become a member or make a contribution, please go online to www.brbc.ab.ca

Alberta Agriculture, Food and Rural Development (AAFRD)

Alberta Environmentally Sustainable Agriculture Program

The Alberta Environmentally Sustainable Agriculture (AESA) Council, created in July 1997, conducts education and awareness programs on manure management, sustainable grazing, riparian management and integrated crop and pest management. Priorities include maintaining and improving water quality and maintaining biodiversity through environmental stewardship by Alberta's farmers, ranchers and food processors.

The AESA Stream Survey is a long-term monitoring program that tracks water quality in Crowfoot Creek in the Bow Basin as well as 22 other streams in agricultural areas across Alberta. The survey is conducted by AAFRD, Alberta Environment, Alberta Health and Wellness, and Agriculture and Agri-Food Canada (PFRA). AESA also conducts an annual tracking survey to explore adoption of beneficial management practices and changes in producer's attitudes toward sustainable agriculture. Information on the 2004 tracking survey is available from AESA Council by phoning (780) 427-3616. (Use the toll-free 310-0000 Riteline)

Irrigation Branch

The Irrigation Branch of AAFRD offers a broad range of engineering, water management and agronomic services to producers using irrigation and the irrigation industry. The Branch carries out a wide variety of research, demonstration and extension activities on matters relating to irrigation agriculture. It is comprised of a team of specialists who provide technical expertise and research related to the determination and quantification of seasonal crop

water requirements and making the most efficient and best use of our limited water resource.

The Branch also assesses water demands and efficiencies and ensures that rehabilitation and maintenance of irrigation district infrastructure is carried out in a sound, cost-effective manner. They are currently developing environmental phosphorus limits for Alberta and are working with industry groups and research organizations to fund and evaluate technologies and management practices that will enhance environmentally sustainable agriculture operations.

In 2002, the Irrigation Branch conducted an in-depth modelling study of the Bow River (and Oldman River) watersheds, exploring scenarios for different water demands and deficits, and the challenges for expanded water use in the 21st century. Information on the study is available through AAFRD's *Ropin' the Web* Internet site at www1.agric.gov.ab.ca.

Alberta Conservation Association

The Alberta Conservation Association (ACA) is a non-profit, non-government group working collaboratively to conserve and enhance Alberta's wildlife and fisheries and their associated habitat. Using funds from donors and fishing/hunting licences, they make grants available to groups involved in conservation work, including riparian habitat restoration projects, amphibian research, studies of aquatic invertebrate biodiversity in the South Saskatchewan River Basin, and Bow River Basin trout monitoring. They also provided financial support for this report. For more information contact the ACA at www.ab-conservation.com or phone 1-877-969-9091 toll-free.

Alberta Environment

In 2003, the Government of Alberta released *Water for Life: Alberta's Strategy for Sustainability,* to show its commitment to the wise management of Alberta's water and to ensure a healthy sustainable water supply. One of the most comprehensive strategies of its kind in Canada, *Water for Life* outlines a series of short-, medium- and long-term actions – worth an estimated $916 million – to be implemented over the next 10 years. The policy paper is aimed at ensuring Albertans have safe, secure drinking water, healthy aquatic ecosystems, and a reliable water supply to support provincial economic development. Learn more about Alberta's *Water for Life Strategy* by going online to www.waterforlife.gov.ab.ca or phone Alberta Environment at (780) 427-6310 for a copy. (Call toll-free in Alberta by first dialing 310-0000)

BRBC Quarterly Information Forum – Mike Murray

In response to the loss of wetlands and the need for consistent direction to guide provincial government departments, municipalities, industry, agriculture, and individuals, Alberta Environment is taking a lead role in the development of a Wetland Policy and Action Plan. The new Policy and Action plan will provide direction for the management of slough/marsh wetlands and peatlands in Alberta and will supersede the 1993 "Wetland Management in the Settled Area of Alberta – An Interim Policy." Work is proceeding on the province-wide wetland inventory and classification system with Ducks Unlimited Canada (DUC), a partner in the North American Waterfowl Management Plan, providing much of the behind-the-scenes expertise.

Alberta Environment is also working on an Aquatic and Riparian Condition Assessment for the South Saskatchewan River Basin (SSRB). The study will examine human influences on hydrology, riparian management and water quality in all mainstem reaches, including the Bow River. The goal of the project is to provide a quantitative description of the relative ecological status of the river system. It will complement the qualitative *Strategic Overview of Riparian and Aquatic Condition* assessment recently completed by expert panels within the SSRB.

Alberta Environmental Farm Plan Company

The Alberta Environmental Farm Plan Company (AEFP) works to help agricultural producers identify and address environmental risks and opportunities on their operations. The organization sponsors free local workshops for agricultural producers that emphasize water-related issues. For more information on the AEFP visit their website at www.albertaefp.com or call their head office toll-free at 1-866-844-2337.

Alberta Irrigation Projects Association

The Alberta Irrigation Projects Association and its member Irrigation Districts work actively with producers, area schools, professional organizations and other interest groups to provide up-to-date information about water management in southern Alberta. They give producers hands-on experience in water management and irrigation efficiency through field tours, presentations and publications. In partnership with their members and other organizations they are involved in a large number of conservation projects in the irrigation districts. For more information on irrigation-related water projects in the Bow River Basin, phone (403) 328-3063 or check out their website at www.aipa.org.

Alberta Lake Management Society

The Alberta Lake Management Society (ALMS) promotes understanding and comprehensive management of lakes and reservoirs and their watersheds. ALMS and its members are active across Alberta in providing support to individuals, local communities, educational institutions, governments and industry that are interested in lake and watershed management. ALMS is also widely recognized through Lakewatch, its community-based lake sampling program. Lakewatch is a volunteer-based monitoring program that benefits lake users and provides water quality data to Alberta Environment. The volunteer program is a great success because it empowers citizens to become active in their own lake community, and gives them the ability to understand and have a positive impact on the management of their lake. For more information about getting involved with ALMS and the Lakewatch program, visit www.alms.ca or call (780) 492-1294.

Cows & Fish

The Alberta Riparian Habitat Management Society, better known as Cows and Fish, works with landowners and community groups to foster a better understanding about riparian areas and how their management can enhance landscape health and productivity. They provide knowledge, options and tools for ecosystem and resource management in riparian areas, whether agricultural, acreage or lakefront. Cows and Fish sponsors community workshops and field days, a grazing management school for women, a youth education program and other activities that give people ways to personally address riparian concerns and evaluate or monitor the effectiveness of their actions.

Their approach is to strongly encourage communities and individuals to identify local issues and concerns, help set the direction to address those issues, and lead the decision-making process on how to make changes. Cows and Fish is funded by Alberta Environmentally Sustainable Agriculture, Canada-Alberta Beef Industry Development Fund, Canadian Adaptation and Rural Development Fund, and Wildlife Habitat Canada. Information on the Cows and Fish program is available on the website at www.cowsandfish.org or phone the program manager at (403) 381-5538.

Ducks Unlimited Canada

Ducks Unlimited Canada (DUC) is a national, private, non-profit organization that has been committed to wetland conservation for more than 65 years. The organization conducts wetland and environmental research and works to change policy in favour of wetland and habitat conservation. DUC also delivers wetland and environmental education programs to teach Canadians about wetlands and the need to conserve them and is a participant in the North American Waterfowl Management Plan. Locally, DUC has carried out more than 80 conservation projects in the Bow River Basin, particularly in the prairie eco-region within the Western, Eastern and Bow River Irrigation Districts. The waters of the Bow River also feed a large number of DUC wetland conservation projects located outside the Bow River Basin.

The first DUC project within the Bow River Basin was developed in 1941 at Lost Lemon (Lonesome) Lake within the Bow River Irrigation District (BRID). It is now part of a major DUC conservation landscape known as the Circle E Project. Other DUC projects in the Bow River Basin followed, designed either to restore traditional wetland habitat or improve upland habitat and return native grasses to areas surrounding wetlands. The most important habitat for the broad range of waterfowl species is in the flatter terrain, with warmer, more productive waters, located east of the City of Calgary. More recently, urban outreach has become important within the City of Calgary. More information on DUC is available on the Internet at www.ducks.ca or by calling their Calgary office at (403) 201-5577.

Mark Bennett

Environment Canada

Water Quality Monitoring

Monitoring of the upper Bow River within Banff National Park falls under the mandate of the federal government. The Ecological Research Division of Environment Canada (through an agreement with Parks Canada) has monitored water quality monthly, at two locations on the mainstem of the Bow River, since the early 1970s (Bow River above Lake Louise, Bow River at the Banff Park Boundary above Canmore). The parameter list has changed through the years, but currently includes physical parameters, major ions, metals, nutrients, and bacteriological parameters. Monitoring reports were published in 1974, 1976, 1980, 1993, and 2003.

Hydrometric Monitoring

Water Survey of Canada (Meteorological Service of Canada, Environment Canada) monitors discharge at 22 locations in the Bow River Basin. Six of these locations are on the mainstem of the Bow River (Lake Louise, Banff, Calgary, Carseland, Bassano, and the confluence with the Oldman River). The remaining sites include tributaries and irrigation withdrawal/return flow canals. Water Survey of Canada and Alberta Environment share the costs of hydrometric monitoring in Alberta through a cost-sharing agreement.

Prairie Provinces Water Board

The Prairie Provinces Water Board (PPWB) is a federal-provincial government organization responsible for the administration of the 1969 Master Agreement on Apportionment. That agreement provides for equitable sharing and protection between Alberta, Saskatchewan and Manitoba of eastward flowing streams. The PPWB also provides a forum to help prevent and resolve inter-provincial water issues and to facilitate cooperation for sustainable development of inter-provincial streams. The PPWB monitors stream flow and water quality at inter-provincial river locations, including the South Saskatchewan River. Environment Canada provides administrative and technical support to the board and conducts its monitoring program.

Grassroots Watershed Groups

Numerous watershed groups and other organizations are working to improve water quality and ensure water quantity in the Bow River Basin. Counties and Municipal Districts throughout the basin are involved in water conservation and restoration projects. Contact the individual municipal government offices and ask for more information from their watershed coordinator or an agricultural fieldman.

Mark Bennett

Grassroots watershed groups also exist in most sub-basins of the Bow River Basin, including:

- Bow Riverkeeper
- Crowfoot Creek Watershed Group
- Elbow River Watershed Partnership
- Farmers of the Elbow Watershed
- Ghost Watershed Alliance Society
- Nose Creek Watershed Partnership
- Red-Bow Regional Watershed Alliance
- Rosebud River Watershed Partners
- Sheep River Preservation Society
- Stobart Lake Focus Group
- Upper Little Bow Basin Water Users Association
- Waters of Wheatland Committee

Note that the Rosebud River Watershed Partners and Upper Little Bow Basin Water Users Association are located outside the Bow River Basin, but depend on the diversion of water from the basin. For contact information for any of these groups, please phone the Bow River Basin Council at (403) 254-3419.

Pheasants Forever

Pheasants Forever is a non-profit organization dedicated to the protection of pheasant and other wildlife populations. The group works to restore upland wildlife habitat through conservation and water quality projects. They redevelop riparian areas on prairie farmland by planting buffer strips along streams, creating wildlife travel lanes and nesting cover, and protecting cattail marshes. Pheasants Forever works closely with the AIPA, DUC and other organizations. For information on their work in the Bow River Basin visit the website at www.pheasantsforevercalgary.com or phone the Calgary office at (403) 802-3777.

Trout Unlimited Canada

Trout Unlimited Canada is a non-profit group dedicated to the conservation, protection and restoration of Canada's freshwater resources and their watersheds. The group maintains its head office in Calgary and has several projects in the Bow River Basin. For more information check their website at www.tucanada.org or phone toll-free 1-800-909-9091.

Watersheds of Alberta

Watersheds of Alberta, the Alberta Water Quality Awareness Team, is a new group interested in raising awareness of the water quality of the lakes, streams and wetlands in rural and urban communities across the province. The group acts as a provincial umbrella organization for Alberta groups interested in watershed enhancement, protection or conservation initiatives. They also provide advice and tools to people wishing to start new watershed groups. One of their main objectives is to provide a means for existing grassroots watershed groups to communicate more readily with one another and with the public. They also sponsor the Alberta Water Quality Awareness Day (to be initiated in June 2005) and hope to engage Albertans in sampling water bodies in their home communities. Information is available on-line at www.albertawatersheds.org or call (403) 350-2163.

Fish Rescue – Trout Unlimited Canada

11.2 What has Changed?

The overall objectives of the 1994 and current State of the Bow River Basin reports have been to provide a picture in time of the challenges and opportunities for improving water quality and aquatic habitat and ensuring a reliable supply of water in the river and its tributaries. Several of the more than 30 objectives set by the 1991 Bow River Task Force Report had been accomplished by the time the 1994 State of the Bow River Report was published. A decade later, many more of those objectives, as well as new ones, have been initiated and some are nearing completion. Major accomplishments since publication of the 1994 State of the Bow River Report include:

- Water and wastewater treatment plants have been upgraded throughout the basin. The improved treatment of bacteria and nutrients, in particular, has greatly decreased the loading of these pollutants into the Bow River. Several communities have joined to develop sophisticated regional wastewater treatment facilities that would otherwise not be feasible for individual communities. Treated wastewater is also being used for spray irrigation, wetland creation and restoration, and other innovative projects.
- Water conservation measures have been implemented, and low water volume bathroom fixtures and water metering have been mandated or fostered in Calgary and other communities in the basin. As a result, per capita water use has declined.
- Many local water stewardship groups have formed across the basin. An umbrella organization, Watersheds of Alberta, has been created to coordinate their efforts and assist in inter-group communications.
- A few river management zones have been established. The BRBC has been designated as the official Watershed Planning and Advisory Council for the basin.
- Volunteer water quality monitoring and visual assessment programs have been initiated.
- Public awareness of water-related problems and education on possible solutions has increased. Storm drain marking programs are well underway and toxic waste round-ups are a regular feature in many rural and urban communities.

Shore Keepers Tour – Mark Bennett

Chapter 12

Prairie Storm – A.MacKeigan

Chapter 12

What Needs to Change?

12.1 Conclusions

The Bow River Basin is a large, diverse system that varies greatly along its length, both in terms of the status of its water resources and impacts from human activities. In some reaches of the Bow River, water quantity is adequate, water quality is improving and aquatic ecosystems are generally healthy. However, the health and status of the river deteriorates along its length and there are several serious issues of concern. This chapter identifies the greatest human impacts on the basin, including the most immediate threats and future challenges to its health.

Water Quantity

Streamflows in the headwaters of the Bow River are relatively unchanged, but the demand on water quantity in headwater communities continues to grow. Most of the Bow River is highly altered from its natural flows. Dams for hydroelectric generation, located in the upper reaches and major tributaries, store water during the spring and summer and release it during the year, reducing the spring and summer flows and increasing winter flows. In the lower reaches, water withdrawals for irrigation and municipal uses also reduce streamflows, particularly during the summer. Currently, there are insufficient flows to meet all the demands within the lowest reach of the Bow River, resulting in the degradation of aquatic and riparian habitats.

Water Use and Allocations

Irrigation districts and municipalities are allocated the majority of the licensed volume of the Bow River (approximately 76% and 18%, respectively), with additional licences for industry, recreational facilities and smaller irrigators, other agricultural users and communities. In general, peak demands for most users occur during the summer months. When the water is most required, the flows in the river may be too low to permit a full use of the licensed amount. If the water supply cannot satisfy the requirements of all licensees, water is allocated according to the principle of priority in time.

Many of the water licences for the Bow River were issued decades ago, when capacity and limits were not the concern they are today. Licences issued since the early 1990s are subject to minimum flows for fish habitat being met before withdrawals from the Bow River are permitted.

Water conservation efforts are ongoing throughout the basin. Municipalities have implemented strategies that include education for residential indoor and outdoor water conservation, incentive programs for residents and industries, mandatory water metering, and detection and repair of leaks. The irrigation industry has increased the efficiency of its water use. The agricultural industry has initiated more sustainable practices to help reduce impacts. For example, previously cultivated marginal lands have been returned to pasture and wetland use. Zero or minimum tillage practices have been adopted to conserve moisture and reduce sediment runoff. Research into crop varieties and management practices to improve crop yields with less water is ongoing. The biggest change has been the increased efficiencies attained through relining of canals, installation of pipelines, and adoption of high-tech sprinkler systems.

Water Conservation Objectives

The South Saskatchewan River Basin Water Management Plan will recommend Water Conservation Objectives for specific reaches of the Bow River. These will attempt to define the desired balance between water consumption and environmental protection of the river. The Water Conservation Objectives will subsequently be established by the Alberta Government.

Climate Change

Warmer temperatures and receding glaciers within the basin during the last century may be the result of human-induced climate change. One scenario predicts climate change may cause lower spring floods and higher winter streamflows. Because glaciers add to the flows of the Bow River, continued glacial retreat would eventually result in the loss of their contribution. These changes could result in small changes in streamflow in typical years, but substantial declines in drought years in the upper reaches. Research into predicted impacts and potential solutions for climate change in the South Saskatchewan River Basin is ongoing.

Water Quality

Human activities within the basin have greatly influenced water quality. The headwaters of the Bow River contain pesticides and persistent organic pollutants, the result of long-range atmospheric transport and deposition. Non-point source of pollution need to be identified. Water quality declines along the length of the Bow River, with higher concentrations of nutrients and pesticides in the lower reaches due to land use and disturbance, municipal and industrial effluents, and agricultural practices. Treatment upgrades of the effluents discharged by municipalities and industries have improved bacteria and nutrient concentrations during the last few decades. However, effluent quality will need to continually improve in order to meet the growing demands of future populations, and agricultural, industrial and recreational activities.

Nutrient Enrichment

Municipal wastewater effluent is the largest point source contributor of nutrients to the Bow River. Moderate increases have resulted in the highly productive sportfishery downstream of Calgary, but excessive productivity can lead to poor water quality and negative changes to aquatic ecosystems. Ongoing upgrades to municipal wastewater and stormwater treatment are likely to result in continued improvements in water quality. The implementation of total loading limits in Calgary will set an upper limit for pollutant discharge, regardless of future increases in population and growth. Agricultural runoff also contributes nutrients in the lower reaches, increasing the productivity of the system.

Riparian Areas

The health of riparian areas degrades along the length of the Bow River. During the past century, hydroelectric dams and water withdrawals have altered the natural flood regime of the river, negatively affecting riparian areas. Changes in seasonal inundation have resulted in the poor regeneration of cottonwood trees. If significant recruitment does not occur, the riparian forests, and the important wildlife habitat and structural function they provide, could be gone in the next 100 to 150 years. Invasive plants and weeds have become established throughout the riparian zone, particularly in the more heavily cultivated lower reaches of the river. Irrigation reservoirs and canals provide additional riparian and channel habitat, but cannot replace natural habitat within the basin. Educational programs are helping to alleviate the impacts of ranching and agricultural practices on riparian areas, but only a historic flood regime may be able to restore the riparian areas along the lower Bow River.

Wetlands

Throughout the basin, wetlands have been drained, tilled or filled to allow for rural and urban development and to enhance agricultural production. While many wetlands still remain in association with native grassland, information quantifying existing and drained wetlands is not available, making it difficult to manage this important resource. Some previously drained agricultural lands have been converted back to wetland use, but restoration cannot keep pace with the rate of wetland loss. Irrigation canals and reservoirs provide abundant staging and moulting habitat. Irrigation right-of-ways also offer nesting habitat, but their success in these areas is poor. Preservation and restoration of wetlands and associated habitats need to be raised to a higher priority. Recent progress includes the development of Canada's first wetland protection plan for a major urban center by the City of Calgary. Alberta Environment is helping to develop a Wetland Policy and Action Plan for the province.

Fish Habitat Alterations

Fish habitat in the upper reaches is limited by the large daily fluctuations in streamflows and large seasonal fluctuations in reservoir water levels that result from hydroelectric facilities. In the mid and lower reaches, flows are re-regulated and municipal wastewater effluents stimulate biological production. These factors have improved fish habitat and have contributed to the Bow River's world-class sportfishery. However, several of the dams and weirs present barriers to fish movement along the river. Cumulative water withdrawals greatly reduce the flows of the river at the lowest reach, impairing fish habitat. Under lower flow conditions, water temperatures can rise and oxygen concentrations can drop, stressing fish. Heavy angling is another pressure facing fish populations. Continued improvements in weir design and effluent quality should improve some of these conditions, but the return to a more natural state would require substantial changes in water use.

Fish Introductions

The distribution and populations of fish species within the Bow River Basin have changed during the last century, particularly in the upper and mid reaches of the river. Populations of the native cutthroat and bull trout have been substantially reduced and are currently

found only in the headwaters and in some tributaries. Introduced rainbow, brown and brook trout have largely replaced these native species. Some of the non-native fish introductions were accidental, while others were done purposefully to improve angling opportunities. Restoration programs to re-establish native populations are ongoing throughout the basin.

Future Challenges

Because of the variability in natural flows of the Bow River, licences for water allocation have occasionally exceeded the actual availability in the river. The combination of increasing numbers of licences, increased use of allocated water by licensees, and low flow or drought years could affect many municipalities, industries and irrigators, as well as water quality and aquatic ecosystems. As the population in the basin grows, impacts such as stormwater runoff and additional demands for instream flows for assimilation of wastewater effluent will likely become greater challenges for urban areas and downstream users. The overall challenge will be to ensure adequate supplies of water for ecosystem requirements, as the demands on water for human uses continue to grow.

12.2 Recommendations

As discussed in Chapter 11, many positive changes and accomplishments have occurred throughout the basin since the 1994 State of the River Report was published. However, additional changes are required for the basin's water resources to be managed sustainably and effectively, now and in the future. The recommendations included in this chapter are not meant to be an exhaustive and all-inclusive list. Rather, this section focuses on a few key issues that were identified as high priorities for the BRBC during the compilation of this State of the Bow River Basin Report. While many of these recommendations suggest a leadership role by the provincial government, every person in the Bow River Basin has the opportunity to influence future watershed management. The six major recommendations are:

1. Development of the Bow River Integrated Watershed Management Plan
2. Appropriate use and sharing of technology
3. Preparation of a Water Balance Sheet
4. Continued research and monitoring
5. Public consultation and engagement
6. Pro-active contingency planning

Integrated Watershed Management Plan

The South Saskatchewan River Basin Water Management Plan is currently being developed. As this project nears completion, the development of an Integrated Watershed Management Plan specifically for the Bow River Basin should be a priority. A source water protection strategy should be incorporated into this plan. The federal and provincial governments share jurisdiction over much of the headwaters of the basin. Communication among departments is essential to ensure that policies are integrated and comprehensive. Reaches on the Bow River should be organized based on sub-watershed boundaries and not the political, infrastructure or other boundaries of the past.

Enhanced coordination between land use policies and watershed management planning is needed. For example, enhanced water conservation and watershed management protection could be built into policies such as the Natural Resource Conservation Board guidelines, Forest Management Agreements, the Municipal Government Act, and Provincial Land Use Policies. These policies should be mandatory and enforceable.

Use of Technology

Technologies, such as Geographic Information Systems (GIS), should be used as part of an overall strategy to apply the benefits of advanced graphic, database, programming and analytical tools to water management planning and resource assessment. There should be a greater focus on the sharing of state-of-the-art technologies, protocols, models, and digital data between agencies, including provincial and federal governments, universities, municipalities, and industry. These techniques should be applied to watershed management, land use management, and habitat and wildlife assessments throughout the basin. For example, while many of the wastewater treatment plants in the basin are state-of-the-art, further advances in technology will be required to maintain total loading limits as populations continue to grow.

Water Balance Sheet

The generation of a complete Water Balance Sheet is essential for the future management of the Bow River's water resources. Alberta Environment currently uses a water balance model for the South Saskatchewan River Basin (the Water Resources Management Model) and a daily operation model for the Bow River. However, if the public is to be consulted in water management decisions within the basin, a more simple application and presentation of these tools is required. A full

accounting of the available water and the inputs (e.g. tributaries, precipitation, effluent and other discharges), outputs (e.g. evaporation and withdrawals) and storage within the Bow River Basin should be prepared. The account should include surface water and groundwater, as well as precipitation and glacial ice. Seasonal and annual variation of the water resource and its uses should also be incorporated.

In order for the water balance sheet to be as accurate as possible, the Government of Alberta should reinstate mandatory water use reporting for major water users. While this may not be feasible for the smaller, private licence holders, all larger private licences should submit annual water use reports. The ability to track actual consumption and return flows within the basin is essential for effective water use planning and allocation.

Ongoing Research and Monitoring

Improved watershed management will rely on improvements in data collection and coordination. Research and monitoring should continue to focus on existing high priority areas of surface water quantity and quality. It is important to maintain, and in some cases, re-establish the water quality and streamflow monitoring stations that are, or have been, part of the federal and provincial networks. The following data gaps have been identified and should also receive attention:

- Groundwater data across the basin
- Land use data, particularly from agriculture and intensive livestock operations
- Impacts of non-point sources of pollutants on water quality across the basin
- Long-term water quality monitoring stations in Reaches 4 and 5
- Aappropriate management of camping facilities and off-highway vehicles in public lands to prevent impacts on riparian areas and water quality
- Wetland inventory, including a drained wetland inventory on a scale suitable for planning
- Glyphosate should be included in water quality monitoring programs along the lower reaches of the river

There should be more frequent data collection and reporting and a greater basin-wide integration of water quality and quantity issues. Increased coordination between municipalities, federal and provincial governments, and non-government organizations are needed for more efficient data collection. Data sharing agreements should be developed in order to prevent duplication of effort. While monitoring programs are dependent on each organization's objectives, monitoring protocols (frequency, variables, detection limits, etc.) should be standardized, where possible, to allow comparisons. For example, future calculations of the Alberta Water Quality Index for the Bow River should include the stations in the headwaters of the basin, not just the provincial stations. The collection and organization of water licensing information also requires standardization and better record keeping.

Public Consultation and Engagement

An ongoing challenge is how best to get people involved and keep them involved in watershed management. An informed, engaged public is an essential component in the success of future watershed management planning. Well thought out, detailed and feasible water conservation programs can be developed, but in many cases they must be implemented by individual members of the public to be effective. When the public is consulted and involved in formulating these conservation programs, their interest and willingness to implement them will be that much stronger. In order to bring about positive changes, the public must be well informed of its role and capacity to influence, both negatively and positively, the state of the Bow River Basin's water resources. The many stewardship organizations, government bodies, community groups, academic institutions, and industries that operate within the Bow River Basin share a common goal of reaching the public, and their efforts should continue.

Pro-active Contingency Planning

Contingency planning is critical to identify emerging issues and adequately deal with future changes to water supply and demands on its use. Water management planning and future water allocations and transfers should consider the impacts of global warming, drought, glacier shrinkage, and potential disasters, because it is likely available water resources will decrease.

12.3 How Can You Help?

Rural Residents

Residents of farms and rural communities in the Bow River Basin need to be vigilant about their water supplies. If these water sources are not maintained properly, water quality and quantity can deteriorate, leading to health problems for their families and their livestock and crops. Unless your water supply comes from a municipally administered source, test all water

regularly and treat domestic water. Groundwater and surface water contamination can occur from leaking sewage systems, fertilizer or manure spreading, and pesticide spraying. These pose potential threats to your health and to your neighbour's health.

Other recommendations include:

- Make sure there are no cross connections between raw water and potable water supplies and install backflow prevention devices on all hydrants, pumps and faucets.
- Inspect and pump your septic system every 3 to 5 years at a minimum.
- Fix leaks quickly to prevent loss of water supplies.
- Where water supplies come from individual wells, make sure the wells are properly constructed. Seal abandoned wells and check that well caps are firmly sealed to the casings.
- Handle all agricultural chemicals, fuels and lubricants carefully to prevent contamination and follow minimum distance regulations and recommendations for separation of hazardous materials and water sources.
- Manage manure properly to avoid surface runoff and leaching of contaminants. Divert runoff from manure stockpiles into holding ponds and away from water bodies. Spread manure away from watercourses, leave a buffer strip of at least 30 metres from surface water and incorporate manure into soil within 48 hours of application.
- Fence off riparian areas and buffer zones, and provide off-site watering devices for livestock. Use alternative watering systems such as solar or nose-powered pumps to draw livestock away from waterways.
- Test your soil regularly for nutrient levels, so that you don't add excess nutrients or chemicals that will pollute surface water, groundwater, dugouts or wells.
- Control the timing and intensity of grazing to protect riparian areas.
- Reduce soil and wind erosion by planting permanent vegetative cover, shelterbelts and using reduced tillage.
- Irrigate cropland with treated industrial wastewater to conserve water. However, do not irrigate with wastewater when soil is frozen or snow covered, during intense or prolonged rainfall, and consider distances from seasonal drainage courses, surface water bodies and water wells.

More information on water sources and their protection is available through Alberta Agriculture, Food and Rural Development, Agriculture and Agri-Food Canada, Health Canada and the Alberta Environmental Farm Plan Company.

Urban Residents

Residents of urban areas in the Bow River Basin can contribute substantially to improved water quality and ecosystem protection by decreasing their use of water and ensuring that lawn and garden chemical use is minimized. Ensure that pet wastes and leaks of gasoline, oil and other contaminants never enter the river through surface runoff. Studies show that urban residents often overuse lawn and garden chemicals and the excess goes directly into stormwater sewers. Stormwater runoff thus carries pollutants such as fecal bacteria, chemicals, lawn fertilizers, oil and sediments directly to streams and rivers, where they seriously harm water quality.

The way we design our urban landscape can play a significant role in the amount of water used and the quality of the water that is returned to waterways. Recommendations include:

- Consider xeriscaping or low water use landscaping.
- When landscaping, limit the use of impenetrable surfaces. Use permeable paving such as wood decks, bricks, and concrete lattice.
- Gutters and down spouts should drain onto vegetated or gravel-filled seepage areas and not directly onto paved surfaces. Splash blocks help reduce erosion.
- Divert runoff from pavement to grassy, planted or wooded areas of your property, so stormwater can seep slowly into the ground.
- Encourage your local government to develop erosion and sediment control regulations or guidelines for construction sites in your community. Get involved in the planning and zoning processes to help make the decisions that shape urban development.

You can play a significant role in creating a sustainable urban landscape. More information on urban and suburban water issues and what individual residents can do to help is available online at www.epa.gov/gmpo/pdf/NPS_Urban-facts_final.pdf.

Get Informed and Involved

You can also help by learning more about water quality and quantity issues. A wealth of information on water and water issues is available from various organizations and on the Internet. Once you know about the issues, take action by contributing your time, expertise or money to one of many stewardship groups interested in the Bow River Basin.

12.4 Closing Statement

This State of the Bow River Basin Report has brought together information from a wide range of sources in order to provide a comprehensive, yet clear picture of the state of the basin and links to human activities. Additional effort and focus are required to ensure protection of the resources of the Bow River Basin. Resolution of watershed management issues is critical, as is the determination of the availability of flows for future allocations. Of great importance is the need to use water more efficiently. Communication and collaboration among those involved in watershed management are essential to ensure the responsible use and conservation of water resources in the basin.

State of the basin reporting is a link in bridging policy changes, new scientific information and public education. It is the aim of the BRBC to continue this reporting every five years, so changes to the basin can be identified and acted on more effectively. It is hoped these conclusions and recommendations provide focus and impetus to move forward. The BRBC looks forward to highlighting the gains made in basin-wide watershed management for the next State of the Bow River Basin Report.

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Glossary

Algae – Simple plants, chiefly aquatic, that are the basis of the aquatic food web for fish and other aquatic animals.

Allocation – Permission for water to be redirected for other than domestic purposes. Agriculture, industry and municipal water users apply to Alberta Environment for a licence to use a set allocation of water. This water licence outlines the volume, rate and timing of the diversion of water.

Aquatic – The components of the environment related to, living in or located in water bodies or their bed and shores, including all organic and inorganic material, plants and animals and their habitat.

Aquifer – An underground water-bearing formation capable of yielding water.

Assimilative Capacity – The ability of a water body to purify or remove contaminants from wastewater.

Baseflow – The groundwater component of a stream's flow.

Baseline – Conditions occurring before and/or during the reference period that serve as a comparison for measurement.

Benthic – The bed or bottom of a water body and associated organisms.

Bio-available – The ability of a compound to be absorbed or interact in the metabolism of an organism.

Bio-solids – The semi-solid waste generated by wastewater and water treatment systems.

Braided – The pattern of two or more shallow, interconnected stream channels.

Channelize – The straightening and deepening of a stream so that water will move faster.

Climate change – A significant change from one climatic condition to another, often used to describe global warming, which is the warming predicted to occur as a result of increased emissions of greenhouse gases.

Confluence – The point at which a tributary merges with the mainstem of a river.

Consumption – The amount of water a licence holder is permitted to divert that is not entirely or directly returned to the water body; also, the difference between the amount of water diverted and the amount of return flow to the system, or the water losses from the system.

Culvert – A pipe used to carry water beneath or through a built structure or embankment.

Cutblock – A specific area of land identified on a forest development plan licence to cut, within which timber is can be or has been harvested.

Dam – A barrier that obstructs the flow of water and is used for water diversion or water storage.

Deciduous – Perennial plants that shed their leaves at some time of the year.

Deposition – Localized accumulation of particles transported by a stream.

Discharge – The volume of water passing a particular point over a specified period of time. Also called *rate of flow* or *flow.*

Dissolved oxygen – The concentration of oxygen available for plants and animals in the water.

Diversity – The variability among living organisms and the complexity of their habitats.

Diversion – The impoundment, storage, consumption, taking or removal of water. Also called *withdrawal.*

Drainage Basin – The area of land drained by a river and all its tributaries. Also called the *catchbasin* or *watershed.*

Ecosystem – A community of inter-dependent organisms together with the environment they inhabit and with which they interact.

Effluent – The liquid waste of municipalities, industries or agricultural operations that is usually released from a wastewater treatment process.

Endemic – A species that is native to or confined to a certain region.

Extirpated – A species that no longer exists in a given part of its former range, but still exists in another area.

Environmentally Significant Area – A landscape or place that is vital to the long-term maintenance of biological diversity, soil, water, or other natural processes, both on-site and in a regional context.

Erosion – The wearing away of the land surface by wind or water. Erosion may be intensified by land-clearing practices.

Eutrophic – Waters with high nutrient concentrations that result in increased biological productivity of the system, including excessive algal growth.

Evapo-transpiration – Loss of water due to evaporation to the atmosphere and transpiration from growing plants.

Fecal coliforms – Bacteria found in the intestinal tracts of mammals. Their presence in water is an indicator of pollution and possible contamination by pathogens.

Feedlot – A confined area for the controlled feeding of livestock.

First-in-time, first-in-right – The principle used to prioritize water rights in Alberta. In existence since 1894, it means the older the licence, the higher the user is on the priority list, regardless of the use made of the water.

Floodplain – The land adjacent to a stream that becomes inundated when flows exceed the capacity of the channel. The size of the floodplain is often defined as the 1-in-100 year floodplain, that is land with a 1% chance of being flooded in any year.

Footprint – The area of the earth taken up by a certain land use, activity or object.

Forb – A non-grass or grass-like plant with a soft, rather than permanent woody stem.

Forage – Grasses, herbs and small shrubs used as feed for livestock or wildlife.

Freshet – Seasonal increase in streamflow due to spring runoff and/or meltwater.

Glacier – A large mass of land ice that is subject to slow movement through growth or recession.

Greenhouse Gas – A gas, such as carbon dioxide or methane, which contributes to potential climate change.

Groundwater – Sub-surface water trapped between rock and saturated soil. The upper limit of the groundwater is the water table.

Habitat – The physical and biological environment in which a plant or animal lives, which provides essential ingredients for survival: food, shelter and water.

Headwaters – The source and upper tributaries of a stream.

Headworks – All structures and associated facilities located at the start or head of a water management project, including the structure for diverting water from a river (dam or weir) and facilities for carrying and storing water (canals or reservoirs).

Hybrid – The offspring of two different varieties or of two different species.

Hydrocarbon – Chemical compounds that consist entirely of carbon and hydrogen, including oil, gasoline and methane.

Hydroelectric – The generation of electricity using waterpower.

Hydrograph – The graphic representation of a stream's discharge or stage over time.

Hydrologic regime – The distribution over time of water in a watershed, including: soil moisture, precipitation, groundwater storage, surface storage, evaporation, and runoff.

Hydrology – Scientific study of the Earth's water resources, especially water quantity.

Hydro-peaking – Rapid and variable daily streamflow fluctuations resulting from quick release of water downstream of a hydro-electric facility, to meet peak power needs.

Impoundment – Artificial storage of water.

Influent – Water or drainage flowing into a reservoir, basin, or treatment plant.

Inorganic – Chemical substances of mineral origin, rather than carbon structure.

Instream Flow – The rate of flow in a river.

Instream Flow Needs – The quantities of water and water quality conditions needed to sustain riverine processes and associated ecosystems over the long term.

Instream Objective – Instream flows targeted by a water system authority. IOs for parts of the Bow River offer some protection of the aquatic environment and may place restrictions on licence holders. This term is expected to fall out of use once Water Conservation Objectives are established.

Invasive – Weed species, classified as noxious or restricted, that have the potential to infest native plant areas.

Invertebrates – Animals without backbones, such as aquatic insects.

Ion – An electrically charged atom or group of atoms.

Levee – An elongated ridge or embankment of loose river sediment deposited along a stream channel.

Licence – Formal permission from a regulatory authority to divert water, catch fish, etc. A licence is required before water can be diverted or used, except for house-hold purposes or residential gardening.

Linear Disturbance – Pipelines, roads, seismic lines, and other uses of land that involve a relatively narrow corridor.

Littoral Zone – The portion of a water body that extends from the shoreline to the limit of where rooted plants can grow.

Mainstem – The primary channel of a river or the primary river in a drainage basin.

Meander – The sinuous bends of a narrow, slow-flowing stream in a wide floodplain.

Mixing Zone – A limited area downstream from a point of effluent discharge, where the initial dilution of the discharge occurs.

Mouth – The area where a stream enters a larger body of water.

Native – Organisms indigenous to a particular habitat, water body or region.

Natural Flow – In a regulated river, the flow that would exist in the absence of human influences; a calculated value based on stream gauge readings, diversions, etc.

No Till – A method of planting crops without prior seedbed preparation, Seed is placed in existing cover crops, sod, or crop residues, thus eliminating tillage operations.

Non-native – Organisms foreign to a particular habitat, water body or region.

Non-point source – Runoff from diffuse sources such as fields and roads.

Oligotrophic – Waters that have low concentrations of nutrients, resulting in low biological productivity of the system.

Oilfield injection – The addition of water into an oil-bearing formation to increase the amount of oil that can be extracted.

Organic – Naturally occurring, carbon containing compounds that form the basis of living organisms.

Outfall – The place where a pipe or channel discharges to a water body, or the material being discharged at that place.

Pathogen – A virus, bacteria or other life form that produces or is capable of producing disease.

Phytoplankton – Tiny plants, including algae, that live in water.

Point Source – Runoff that enters a water body via a pipeline, outfall or other specific source.

Pollutant – A substance that, in sufficient concentration, will render water, land or another system unusable or harmful.

Primary Treatment – The first stage of wastewater cleaning; removal of floating material and solids that settle out.

Reach – A portion of a stream, often uniform with respect to discharge, size, slope, etc. In this report, it also refers to the watershed surrounding the reach.

Recharge – The process by which water is added to saturated soil, such as an aquifer, usually by percolation from the soil surface.

Recorded Flow – Actual flows measured at a stream's hydrometric monitoring station.

Reservoir – A pond, lake or basin, either natural or artificial, for the storage, regulation and control of water.

Return Flow – Water that has been withdrawn from a river that is returned unused or after use, including treated wastewater discharges or water from irrigation canals that is not used on crops. Sometimes water is withdrawn from one stream, but returned to another.

Riparian – Adjacent to streams, lakes or wetlands, where water and land interact. The land beyond the bank of a water body is referred to as the *riparian zone*.

Runoff – The part of precipitation, snowmelt, or irrigation water that runs off the land into streams or other surface water.

Run-of-river – Hydroelectric facilities that do not have reservoirs. The water is passed through the generation plant as soon as it arrives from upstream.

Salinity – The percentage of salt in water.

Salinization – The precipitation of soluble salts within the soil or the evaporation of mineral-rich water from the soil that leaves salts behind.

Secondary Treatment – The second stage of treatment for cleaning wastewater; designed to reduce organic material and suspended solids to acceptable levels.

Sediment – Very small particles of mineral or organic materials.

Sedimentation – The process of material settling out of water.

Spawning – Laying eggs (refers to fish, in particular).

Spring Groundwater that seeps out of the earth, where the water table intersects the ground surface.

Staging area – A temporary gathering place for migrating birds to rest and feed.

Stormwater – Surface runoff resulting from precipitation in an urban area.

Streambank – The portion of the channel cross-section that restricts lateral movement of water at normal water levels.

Streambed – The bottom of the stream, below the water.

Sub-basin – A part of a river basin drained by a tributary.

Suspended solids – Ultra-fine particles held buoyant in a stream or other water body.

Synoptic survey – An overview of water quality in a water body. Water quality samples are taken from many sites to provide a snapshot of conditions.

Terrestrial – Elements of the environment related to, living in or located on land, including plants, animals and their habitat.

Tertiary Treatment – The third stage of treatment for cleaning wastewater, including disinfection and removal of nutrients.

Tributary – A smaller stream that joins with a larger stream.

Turbidity – A cloudy condition in water, due to suspended solids.

Ungulate – A hoofed, grazing mammal.

Wastewater – Unwanted materials that are dissolved, suspended or carried in water.

Water Conservation Objective – The amount and quality of water necessary for protection of a water body and its aquatic environment, or for recreational, transportation or waste assimilation uses, or management of fish and wildlife, or the water necessary to maintain a rate of flow or water level requirements.

Water Quality Index – A method of summarizing large amounts of water quality data into simple terms for reporting in a consistent manner.

Water Quality Guideline – A numerical concentration or narrative statement recommended to support or maintain a designated water use.

Watercourse – A natural channel through which water runs.

Watershed – The area of land drained by a river and all its tributaries. Also called the *catchbasin* or *drainage basin*.

Weir – A structure over which water flows that serves to regulate water level, divert water or, in some cases, measure flow.

Wetland – An area covered permanently, occasionally or periodically by shallow water, for a sufficient period to support aquatic life. Wetlands include marshes, bogs, sloughs, fens, swamps, muskeg, and ponds, but not rivers or lakes.

Withdrawal – The impoundment, storage, consumption, taking or removal of water. Also called *diversion*.

Notes

Bow River Basin Image:
Landsat 7 TM Bands 321 and drainage boundary draped on CDED
1:250 000 scale
DEM looking west over Calgary.
Data Sources: Landsat 7 and CDED, Geobase®; Drainage Basin
Boundary, PFRA, Agriculture Agri-Food Canada.
Compiled by: P.R.J. Wozniak, Geological Survey of Canada,
Calgary, Natural
Resources Canada Groundwater Program. Vertical Scale: 2:1.